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The five alternatives for the conservation of utilities in military housing proposed by the Deputy Assistant Secretary of Defense (Installations and Housing) are reevaluated in this thesis. When evaluated from the tenants' perspective, the cost effectiveness prioritization of the five proposed DoD alternatives is reversed. DoD

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Economic Incentives for Military Housing Residents to Conserve Utilities

by

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B.S.E.E., University of Washington, 1979

Submitted in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE IN MANAGEMENT

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ABSTRACT

The literature reviewed provides strong evidence that individually metering resident utilities provides an estimated 10 - 35 percent utility reductions simply by providing a financial incentive for tenants to conserve utilities. The two key aspects of individual metering are, the financial incentives for tenants to conserve utilities and the ability to hold tenants responsible for consumed utilities through accurate utility meter readings.

The five alternatives for the conservation of utilities in military housing proposed by the Deputy Assistant Secretary of Defense (Installations and Housing) are reevaluated in this thesis. When evaluated from the tenants' perspective, the cost effectiveness prioritization of the five proposed DoD alternatives is reversed. DoD chose building and equipment improvement as the most cost effective way to conserve utilities but this alternative is only a half measure which ignores economic incentives for the tenants to conserve utilities.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

Since 1974, residential electricity consumption in the United States has increased 162 percent, from 554,960,000,000 kilowatt-hours in 1974 to 899,573,000,000 kilowatt-hours in 1989 [Ref. 1:pg a24]. There is no indication that this rate of energy consumption will diminish in the future. The Navy's recent interest in energy costs was largely stimulated by the sevenfold increase in energy costs which began in 1973-74 with the OPEC oil embargo [Ref. 2: pg 661].

The Navy has always been concerned about having enough fuel to sustain its military operations. However, the Navy has great difficulty in identifying energy efficient and energy inefficient devices since the Navy relies on master metering of utilities on its bases and in its family housing areas. In an attempt to hold down energy consumption in one area of the military budget, Congress passed Public Law 95-82 (1977). This law directed the installation of energy consumption metering devices on military family housing facilities in every state, the District of Columbia, the Commonwealth of Puerto Rico, and Guam. In addition the Secretary of Defense was directed to:

- Establish a reasonable ceiling for the consumption of energy in any military family housing facility equipped with an appropriate consumption metering device;

- Assess the member of the Armed Forces who is the occupant of such facility a charge, at rates to be determined by the Secretary of Defense, for any energy consumption metered at such facility in excess of the ceiling established for such facility pursuant to paragraph 1.

Such charges for excess energy consumption were not to be made to any military tenant until:

- The Secretary of Defense conducts a test program to determine the feasibility of assessing occupants of military housing charges for excess energy consumption;

- The Secretary of Defense provides the written results of such a test program, together with proposed regulations implementing this section, to the Committees on Armed Services and Appropriations of the Senate and the House of Representatives;

- A period of 90 days expires following the date on which the results referred to in clause 2 have been submitted to such committees. [Ref. 3: pg I-2,3]

Congress appropriated $8,500,000 (P.L. 95-101 (1977)) to determine the feasibility of metering all family housing facilities in DoD as stipulated by the guidelines set forth in Appropriations Committees Conference Report H.R. No. 95-650 (3 Aug 1977).

DoD conducted the feasibility study by metering 10,379 out of DoD's approximately 300,000 housing units. The feasibility study was coordinated by the Office of the Deputy Assistant Secretary of Defense (Installations and Housing). The report to Congress on the feasibility of installing meters in all family housing units estimated it would cost:

- $415,000,000 to meter all 300,000 remaining units,
- $ 50,000,000 to purchase minicomputers and software to perform the norm calculations and produce bills,
- $ 32,000,000 annual cost to read and maintain all meters,
- $ 23,000,000 occupant education and increased occupant generated maintenance service calls,
- $118,000,000 replacement cost due to negative retention and morale aspects of metering

The costs of installing and maintaining meters were compared to the estimated 6 percent energy consumption reduction. This reduction would annually save 4,860,000 MBtu or $32,000,000 in 1987 dollars.

In light of the prohibitive costs of installing meters in all housing units, the Deputy Assistant Secretary of Defense (Installations and Housing) proposed four alternatives:

- Alternative I - Meter and Billing of Excess Consumption
  No Reward for Good Conservation
  Net Annual <u>Cost</u> of $42,320,000
- Alternative II - Meter with Full Payment
  Net Annual <u>Cost</u> of $11,657,000
- Alternative III - Meter and Provide Feedback
  Option A - Metering Individual Units
  Net annual <u>cost</u> of $23,000,000
  Option B - Master Meter
  Net annual <u>cost</u> of $15,062,000

- Alternative IV - Building and Equipment Improvement
  Net Annual Savings of $35,527,000

- Alternative V - Meter and Billing of Excess Consumption
  Reward for Good Conservation
  Net Annual Cost of $11,571,000

B. OBJECTIVES

The objective of this thesis is to analyze the five alternatives previously mentioned. The analysis will determine which alternative provides tenants with the greatest incentive to conserve utilities. The five alternatives in the Deputy Assistant Secretary of Defense (Installations and Housing) report are analyzed from the perspective of a landlord. This thesis will analyze the five alternatives from the tenant's perspective.

C. THE RESEARCH QUESTION

The primary research question is to establish which of the five utility conservation alternatives provides the greatest conservation incentive to tenants of military family housing. The five alternatives include:

- Alternative I - Meter and billing of excess consumption with no reward for good conservation
- Alternative II - Meter with full payment
- Alternative III - Meter and provide feedback
- Alternative IV - Building and equipment improvement

- Alternative V - Meter and billing of excess consumption with a reward for good conservation

Secondary research questions needed to support the primary research question include:

- What are current Navy practices toward utility conservation?
- How effective have conservation efforts been in Navy housing at La Mesa Village, Monterey, California?
- What are the conservation consequences of master metered housing units?
- How successful are utility conservation practices in master metered residential housing units?

D. SCOPE, LIMITATIONS AND ASSUMPTIONS

1. Scope

This thesis will focus on the tenant's perspective on the five utility conservation alternatives proposed in the Congressional report by the Deputy Assistant Secretary of Defense (Installations and Housing).

Public Law 95-82 (1977) and the Deputy Assistant Secretary of Defense (Installations and Housing) report references to "utilities" are synonymous with "energy" such as electricity, oil and gas. This thesis will expand the definition of "utilities" to include electricity, oil, gas and water, since all four of these resources make up the Navy's monthly utility billing.

The increased cost of all utilities and the diminishing quantity of potable water in the Western United States makes water conservation a logical extension of the term "utilities".

2. Limitations

Current Navy utility conservation practices will be restricted to the Navy military housing complex at La Mesa Village in Monterey, California as a typical application of Navy conservation practices and policies. Due to the difficulty in obtaining extensive historical utility consumption data from both the Navy and the utility companies, historical utility consumption data is primarily restricted to 1989-92.

The thesis is directed toward establishing which Navy wide policy would provide the greatest incentive for military housing tenants to conserve utilities. Consequently, this thesis will argue the pros and cons of master and individual metering but not discuss the overall cost of either master or individual metering.

Advances in meter reading technology will not be considered in this thesis. The impact of remote meter reading, inaccessible meters and time-of-use metering will not be considered. This thesis will restrict meter reading technology to its simplistic form of standard meters that can be read by a meter reader on a monthly basis to determine tenant utility consumption.

The pros and cons was well as the engineering and economic implications of various utility conservation measures (insulation, solar hot water heating, flow restrictors in shower heads, fluorescent lighting, etc...) will not be discussed. Although utility efficient devices have a definite impact on reducing monthly utility consumption, this thesis will focus on tenant incentives to conserve utilities and not on actual utility conservation measures.

The costs of implementing the first four alternatives will be those costs which are identified in the Deputy Assistant Secretary of Defense's report to Congress on the feasibility of installing meters in all military housing units. No original costs for the first four alternatives will be derived in this thesis.

3. Assumptions

It is assumed that when utility consumption is reduced, a corresponding reduction in utility costs is also realized. It is implicitly assumed that the intent both of P.L. 95-82 (1977) and the Navy's utility conservation policy is to reduce operating expenses related to Navy military housing.

This thesis presumes that the Navy would not benefit from a utility conservation measure which decreased energy consumption but required the same level of funding expenditure. This assumption is based on the Navy's requirement for an economic analysis and a specific payback period before a conservation measure is approved. For example, it would be illogical for the Navy to replace an inefficient 400,000 Btu oil fired boiler with a new gas fired boiler that could do the same job producing only 200,000 Btu if higher operations and maintenance costs for the new boiler offset fuel cost savings relative to the old boiler. Conservation for conservation's sake is not the motivating factor in conserving utilities - reduced operating costs (money) is the motivating factor.

E. LITERATURE REVIEW AND METHODOLOGY

1. Literature Review

The majority of research focuses on the Deputy Assistant Secretary of Defense's five alternatives proposed in the March 1980 Congressional report. The foundation for this thesis rests on the March 1980 Congressional report. This report is presented from the perspective of a landlord. This thesis analyzes the same alternatives from the perspective of the tenant.

Lieutenant Walton [Ref. 4] examined the costs and benefits of electricity metering at the Naval Postgraduate School in 1972. His analysis indicated that individual meters would be justified if metering could realize an annual savings of electricity in the range of 2.1% to 7.4%. His thesis only analyzed the commercial/industrial electricity consumption at the Postgraduate School, not the electricity consumption at the military housing complex. The thesis concluded that similar analyses should be conducted at other Navy installations to determine the amount of electricity savings that would be required to justify metering. [Ref. 4]

This is a logical extension of Lt Walton's thesis, it looks at the residential portion of the Naval Postgraduate School but only looks at the benefit of metering utilities and not the associated costs.

2. Methodology

The primary method used in this thesis is archival research. The five utility conservation alternatives presented in the Congressional report of March 1980 has driven this research toward articles published since 1977. These articles deal with the utility conservation incentives associated with master metered housing units.

This thesis assumes a direct analogy between master metered civilian apartment units, where the landlord pays all utility costs, and master metered military housing units, where the Navy pays all utility costs. A small amount of data on recent utility consumption was gathered to provide realistic numerical examples for the implementing the five alternatives.

Economic principles are then applied to each of the five utility conservation alternatives to analyze which alternative provides the tenants with the greatest incentive to conserve utilities.

F. DEFINITIONS AND ABBREVIATIONS

A glossary of commonly used terms is provided in Appendix E.

G. ORGANIZATION OF STUDY

Chapter two will review the pertinent literature dealing with utility conservation incentives. Navy regulation/directives will be reviewed for pertinent Navy energy conservation goals and policies. Current literature concerning conservation incentives for master metered housing units will be reviewed.

Chapter three will provide the reader with a background on the March 1980 Congressional report, the demographic make up of the La Mesa Village tenants and housing population, and estimated reductions in utility consumption based on current studies conducted in residential areas of the United States.

Chapter four will discuss the data collected for this thesis and summarize the questions asked to support data gathering.

Chapter five describes all five utility conservation alternatives. The economic incentive for tenants to conserve utilities will be analyzed for each alternative in a subsection to the chapter. Each subsection will also include a possible methodology to implement the alternative in La Mesa Village. The discussion will conclude with the pros and cons of each alternative from the tenant's perspective of conserving utilities.

Chapter six will identify the alternative with the greatest incentive for tenants to conserve utilities. Recommendations for implementation and areas of further research will conclude this chapter.

II. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

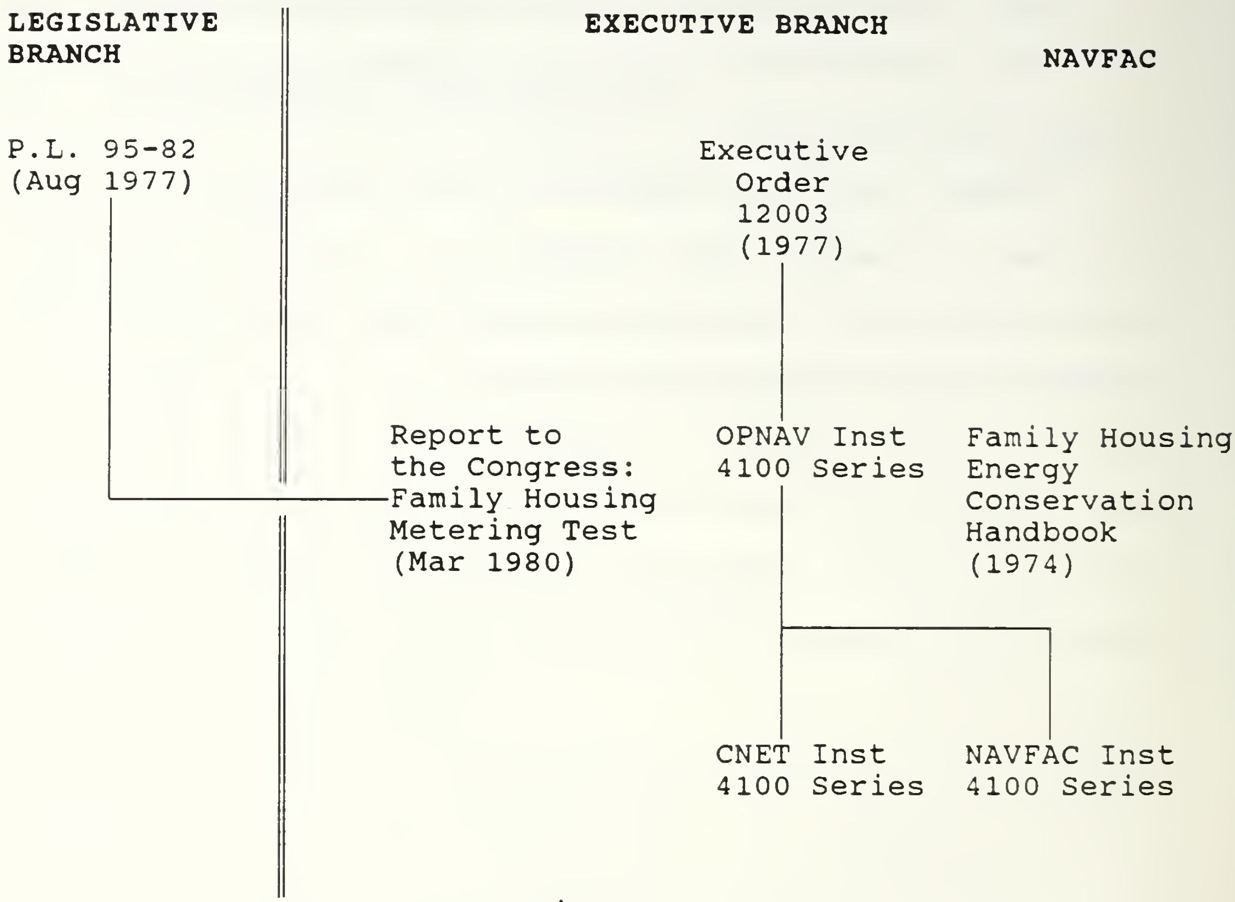

Figure 1
Relationship of Utility Conservation Documents

Public Law 95-82 instructing DoD to meter all military housing virtually died on the vine with DoD's reply in the Deputy Assistant Secretary of Defense (Installations and Housing) Report to the Congress: Family Housing Metering Test. DoD's impetus to conserve utilities is driven by Executive Order 12003 which spawned a series of OPNAV and NAVFAC instructions which promulgated goals and objectives for DoD's utility conservation program.

A. LITERATURE REVIEW

1. Government Literature

Eleven publications were reviewed to gain a perspective on the level of commitment the Government has towards utility conservation. An annotated bibliography has been included at the end of this thesis for the reader who wants a more in depth description of articles reviewed in this chapter.

Two publications, Family Housing Energy Conservation Handbook [Ref. 5] and CNET Instruction 4100.3A [Ref. 6] are both guidelines on how to cut energy costs. They suggest specific utility conservation measures, such as lowering thermostats and sealing up leaking window and door cracks. These two publications will be referenced when Chapter V discusses alternatives to provide feedback to housing occupants.

Two legislative publications, Executive Order 12003 [Ref. 7] and Public Law 95-82 [Ref. 8] were basically the kick in the pants DoD needed to start their utility conservation program. DoD was directed by Executive Order 12003 to reduce energy consumption in existing federal buildings by 20 percent during the period 1975 to 1985. Public Law 95-82 tasked DoD to meter all family housing units and charge occupants for excess utilities consumed.

The Report to the Congress: Family Housing Metering Test [Ref. 3] was DoD's analysis and response to Congress on the proposed metering of family housing units. This publication provides the basis for this thesis. The DoD family housing metering test outlined five utility conservation alternatives from a landlord's perspective. This thesis analyzes these same five alternatives from the perspective of the tenant.

Three Navy instructions assess how well the Navy is doing with its utility conservation program. CNET Instruction 4100.3A [Ref. 6] outlines the Navy's initial goals of reducing energy consumption by 20 percent by FY 1985, 25 percent by FY 1990, 30 percent by FY 1995, and 35 percent by FY 2000. OPNAV Instruction 4100.5C [Ref. 9] was published in 1986, after the 1985 goal of 20 percent was not met. This instruction revised the Navy's energy reduction goals to 6 percent by FY 1990, 12 percent by FY 1995, and 15 percent by FY 2000. Comparing these two Navy instructions shows how aggressive initial conservation goals were. NAVFAC Instruction 4100.8A [Ref. 10] outlines NAVFAC's Navy Family Housing energy conservation policy.

Four publications dealing with the metering of Navy Family Housing units or shore activities provide a perspective on metering impacts on Navy housing occupants and Navy conservation efforts. Costs and Benefits of Extensive Electricity Metering at the Naval Postgraduate School, Monterey [Ref. 4] and Factors that Influence the Implementation of Energy-Saving Technologies at Naval Shore Facilities [Ref. 11] both point out that without an accurate metering system, conservation efforts can not be properly evaluated. Individuals can not be identified or held responsible for wasteful practices. Furthermore, specific conservation measures can not be properly measured for their effectiveness in conserving utilities. Energy Conservation in Navy Family Housing: A "Master-Metered" Approach [Ref. 12] and Energy-Related Attitudes of Navy Family Housing Residents [Ref. 13] relate data on Navy studies conducted on Housing residents to assess the morale and financial impact of metering.

2. Civilian Literature

Eleven publications were reviewed to gain knowledge on expected utility conservation savings due to studies conducted in the private sector.

Six publications discussed direct economic incentives to tenants for conserving utilities. The first three, Effects of Monetary Rebates, Feedback, and Information on Residential Electricity Conservation [Ref. 14], Energy Demand Behavior in a Master-Metered Apartment Complex: An Experimental Analysis [Ref. 15], and A Group Contingency for Electricity

Conservation in Master-Metered Apartments [Ref. 16] showed that financial incentives in master metered units could provide up to a 12 percent savings in utility consumption.

The other three publications, Consumers Without a Direct Economic Incentive to Conserve Energy [Ref. 17], Energy Savings Attributable to Switching from Master Metering to Individual Metering of Electricity [Ref. 18] and Effects of Water Meters on Water Use [Ref. 19] provide data from the private sector and economic theory to support the hypothesis that individually metered dwellings realize substantial utility savings over master-metered dwellings due to direct economic incentives.

Feedback as a Means of Decreasing Residential Energy Consumption [Ref. 20] and How Important is Information Format? An Experimental Study of Home Energy Audit Programs [Ref. 21] discuss the impact that feedback, education, and information format has on housing occupants' utility consumption and conservation.

The economic incentives for landlords and tenants to initiate conservation measures are discussed in Energy Conservation and the Rental Housing Market [Ref. 22], Identifying Barriers to the Success of Consumer Energy Conservation Policies [Ref. 23] and Energy Conservation in Public Housing:It Can Work [Ref. 24].

This thesis draws conclusions from studies of these private sector utility conservation efforts and applies them to utility conservation efforts in DoD.

B. THEORETICAL FRAMEWORK

This thesis is primarily archival research applied to the five alternatives presented to Congress in 1980 by the Deputy Assistant Secretary of Defense (Installations and Housing). The Government literature provides Navy energy conservation policies and goals, while the civilian literature provides data and economic principles which will be applied to the five alternatives explored here.

The five alternatives the Deputy Assistant Secretary of Defense provided to Congress were from the incentive perspective of a landlord who owns a master-metered apartment complex. Looking at the same alternatives from the occupants' point of view leads to a different recommendation if the goal is to maximize energy reduction.

This thesis does not propose anything visionary, revolutionary or startling. The purpose of this thesis is to evaluate the economic incentives for occupants to conserve utilities in master metered dwellings. The contribution of this thesis is that it outlines logical economic principles which could provide direct economic incentives to conserve utilities in DoD family housing units.

III. BACKGROUND

In 1977, responding to the energy crisis of 1973-74, both Congress and the President of the United States instituted legislation to control energy costs in Federal Government Agencies. President Carter issued Executive Order 12003 which provided energy reduction goals for federal activities. This is still driving current energy reduction efforts within the Federal Agencies. Congress attempted to help control energy costs within DoD by authorizing P.L. 95-82 (1977). This law charged military family housing occupants for utilities consumed in excess of a "norm" calculation.

A. EXECUTIVE ORDER 12003

Executive Order 12003 was the first document to effectively address the rising energy costs of the mid 1970s. Related to energy policy and conservation, it was signed by President Carter on 20 July 1977. Using 1975 energy consumption figures as a baseline, Executive Order 12003 called for a 20 percent reduction in the average annual energy use per gross square foot for all federally owned existing buildings by 1985.

Executive Order 12003 spawned the OPNAV 44100.5 series of instructions which outlined the Navy's energy reduction goals and conservation policies. The initial OPNAV instruction, using a 1975 energy consumption baseline, set energy reduction goals of 20 percent by FY 1985, 25 percent by FY 1990, 30 percent by FY 1995, and 35 percent by FY 2000. Executive Order 12003 only required a 20 percent reduction by 1985.

The OPNAV instructions spawned the NAVFAC 4100.8 series of instructions. These outlined NAVFAC's energy reduction goals and conservation policies for NAVFACENGCOM shore installations including Navy Family Housing Units. To track the Navy's progress in meeting its energy reduction goals, the Naval Energy and Environmental Support Activity in Port Hueneme, California was tasked with monitoring energy consumption in the Navy's shore activities on a quarterly basis. By the fourth quarter of 1985, the Navy shore establishment had only realized a 9.02 percent reduction in energy consumption, instead of the 20 percent goal.

In 1986, OPNAVINST 4100.5C changed the energy reduction baseline from 1975 energy usage levels to 1985 energy usage levels. Each shore activity started FY 1986 with their fourth quarter 1985 energy consumption level as their new baseline. The instruction also modified the future energy reduction goals to 6 percent by FY 1990, 12 percent by FY 1995, and 15 percent by FY 2000.

In 1988, NAVFACINST 4100.8A promulgated the OPNAV instruction's policies and goals to the Navy shore establishment. The policy statement asserts that NAVFACENGCOM shall conduct energy management programs in support of the energy objectives and goals, including cost-effective metering and control and management of facility energy systems to curb waste. However, the NAVFAC policy statement ends with the statement: "No restrictions shall be levied on Navy family housing which would reduce quality of life below that normally available to families in the civilian community."[Ref. 10]

As previously mentioned, by 1985 the Navy shore activities had only realized a 9.02 percent reduction in energy consumed relative to 1975 energy consumption levels. By 1990, the Navy shore activities had realized another 8.39 percent reduction in energy consumption relative to the 1985 baseline. This surpassed the established goal of a 6 percent reduction. Currently (1992), the Navy shore activities have realized a 12 percent reduction in energy consumption relative to the 1985 baseline. This meets the established 1995 12 percent reduction goal.[Ref. 25] Pending policy changes within the Navy may increase the 1995 energy reduction goal to 15 percent and keep it at 15 percent through FY 2000. This complies with the most recent Executive Order on Federal building energy reduction goals.

B. PUBLIC LAW 95-82 (1977)

The second document which addressed rising energy costs within the Department of Defense was Public Law 95-82. The House Armed Services Committee Report 95-290 observed that energy consumption by the occupants of military family housing might exceed consumption in similar private sector housing by more than 30 percent. In some cases, usage might be as much as 50 percent higher. The report concluded that the only practical program to control energy consumption would be to change from master-metered units to individually-metered units. Then occupants could be charged for excessive utility usage. Congressional interest in stipulating meters for military housing units and charging occupants for excess energy consumption is not surprising due to the large inventory of housing units in DoD (300,000 units). According to the 1979 Department of Energy Report, DoD consumed 80.4 percent of the energy consumed by the Federal Government in FY 1978.[Ref. 26]

Public Law 95-101 appropriated $8,500,000 for DoD to conduct a feasibility study on metering all military housing units and charging occupants for excess energy consumption. The Deputy Assistant Secretary of Defense (Installations and Housing) coordinated the feasibility study in which 10,379 housing units were metered, involving 19,279 meters.

TABLE 3 - 1
MILITARY FAMILY HOUSING SITES SELECTED

Climate	Military Service	Location	Number of Units
Hot, humid	Air Force	Little Rock AFB, AR	1,535
	Army	Fort Gordon, GA	597
	Marine Corps	MCAS Beaufort, SC	1,276
Hot, dry	Air Force	Cannon AFB, NM	1,012
	Army	Yuma Proving Ground, AZ	290
Moderate with air conditioning	Army	Fort Eustis, VA	1,325
	Marine Corps	MCDEC Quantico, VA	1,168
Moderate, without air conditioning	Navy	PMTC Point Mugu, CA	883
	Navy	CBC Port Hueneme, CA	214
Cold	Navy	NTC Great Lakes, IL	2,076
Total			10,376

A total of 19,279 meters were installed at a total cost for design and installation of $5,407,575, for an average installation cost of $521 per unit metered or $280 per meter installed. There was, however, considerable variation in the cost of metering individual units from a low of $129 to a high of $5,536 per unit. 1226 units estimated to be extremely expensive to meter were dropped from the test program, leaving 10,376 units metered. It was estimated that in certain cases costs to install necessary meters would have exceeded $35,000 per unit. [Ref. 3:pg 7-1]

Concurrent with the design and installation of meters was the creation of a computerized billing system. To charge occupants for excess energy consumption, a "norm" calculation or energy consumption ceiling was compared with actual occupant energy consumption. The norm was broken down into six major energy loads: appliances and lighting; cooking; domestic hot water; pilot lights; heating and air conditioning; and miscellaneous energy consumption. Each one of these six major energy load norms was based on technical factors specific to each housing unit. Technical factors included building construction type, heating fuel type, number of bedrooms, square footage of windows, building insulation, window and door drafting, etc... The algorithm to calculate one norm for one housing unit for a 30-day billing period involved 21 calculations and 289 pieces of data. Data requirements increased if the billing period was extended or there was more than one utility servicing a housing unit.

By 1 September 1978, the meters had been installed, the norm algorithm tested and the mock billing operation commenced. From September 1978 to December 1979, monthly energy consumption data was gathered at the ten sites. Mock bills were generated and sent to housing occupants residing in the 10,376 surveyed units participating.

The metering feasibility study ended December 1979. The Deputy Assistant Secretary of Defense submitted a report to the Congress: Family Housing Metering Test, on 1 March 1980. The Report to the Congress estimated that metering all remaining family housing units in DoD and instituting a monthly energy billing system would cost:

- $415,000,000 to meter all 300,000 remaining units,
- $ 50,000,000 to purchase minicomputers and software to perform the norm calculations and produce bills,
- $ 32,000,000 annual cost to read and maintain all meters,
- $ 23,000,000 occupant education and increased occupant generated maintenance service calls,
- $118,000,000 replacement cost due to negative retention and morale aspects of metering

In keeping with Congress' intention to provide energy conservation incentives to military family housing occupants, the Report to the Congress proposed four alternatives to reduce energy consumption in family housing. The first three alternatives all involve individual metering of housing units. This was shown in Table III-2 to be prohibitively expensive. The fourth alternative was "business as usual," except existing buildings and equipment would be retrofitted with energy conservation measures (attic insulation, double paned windows, low water flow devices, electronic ignition vs pilot lights). In addition, occupant education programs would be instituted on energy conservation practices.

The summary and recommendations of the Family Housing Metering Test concluded,

> The result of the metering test suggest that the legislation as now written should not be implemented. While retrofitting existing housing for metering and billing occupants is feasible, though extremely costly, the norm for determining appropriate energy allowances is not sufficiently accurate to bill individuals. The Department of Defense has concluded, based on results of

tests, that the best approach to energy conservation in family housing is a combination of continuing aggressive consumer eduction coupled with increased emphasis on energy conservation facility improvement.[Ref. 3: pg ES-1]

C. FAMILY HOUSING POLICY

It is current practice for the Government to provide military housing for its service members. Service members who accept Government quarters do not receive BAQ (Basic Allowance for Quarters) or VHA (Variable Housing Allowance). Instead the service member receives housing at no cost and all utilities are paid by the Government. Occupants are responsible for their own telephone and television costs.

IV. METHODOLOGY

A. DESIGN

This analysis takes the approach that the Report to the Congress: Family Housing Metering Test (March 1980) was written from the perspective of the landlord, considering economic incentives for landlords. It did not consider economic incentives for the tenant. Analyzing alternative economic incentives helps identify which alternative provides the tenant with the greatest incentive to conserve utilities.

This thesis investigates the four alternative economic incentives provided in the Report to the Congress: Family Housing Metering Test. Each alternative and its corresponding economic incentive for utility conservation is presented and analyzed.

The alternative analysis of the economic incentives makes this research effort primarily archival. Data on monthly utility consumption was obtained from the La Mesa Housing Office, the Naval Postgraduate School Public Works Department and the Naval Energy and Environmental Support Office in Port Hueneme.

The literature on energy reduction studies is used to support arguments that individual metering creates approximately a 20 percent in utility consumption. In Chapter

V, recent literature is referenced to support this estimate and make analytical projections on projected savings at La Mesa Village.

This thesis is designed to gather energy consumption data which hopefully shows little conservation effort. Then using current literature on utility reduction studies, the hypothesis is presented that individual metering and payments provides the greatest economic incentive for tenants to conserve utilities. Then, an individual metering concept is applied to La Mesa Village. This helps show which alternative provides the greatest economic incentive for tenant utility conservation.

B. DEMOGRAPHICS OF LA MESA VILLAGE

La Mesa Village is the military housing area for officer students attending the Naval Postgraduate School in Monterey, California. La Mesa Village consists of 878 family dwellings incorporated into 323 buildings. All dwellings use electricity for lighting and appliances. Natural gas is used for cooking, heating and hot water heating. The electrical distribution system and natural gas distribution system for La Mesa Village are master metered supplies from Pacific Gas and Electric Company, a commercial utility. Water service to La Mesa Village is provided by two master metered supplies from California - American Water Company, a commercial utility. A breakdown of the number of units in each building is provided in Table 4-1 and Appendix A.

TABLE 4-1
LA MESA VILLAGE DWELLING UNIT DEMOGRAPHICS

Units per Building	No. of Buildings	No. of Units
1	80	80
2	117	234
3	17	51
4	72	288
5	12	60
6	18	108
7	1	7
8	5	40
9	-	-
10	1	10
Total	323	878

La Mesa Village started in 1952 when the original 176 buildings were completed and named Wherry Housing. Wherry Housing ranged from single dwellings to buildings with up to five dwellings. In 1961, an additional 94 buildings were constructed and named Capehart Housing. These dwellings ranged from single units to duplexes. In 1965, 30 buildings were constructed and named '65 Housing. These units ranged from three dwelling buildings up to ten dwelling buildings. In 1969, 23 more buildings were constructed and named '69 Housing. These buildings range from four dwelling units up to eight unit dwelling units.

As of 30 July 1992, the population of La Mesa Village included 834 service members and a total population of 2,954. This population level equates to a 95.09 percent housing occupancy rate at La Mesa Village. Forty-four dwellings were vacant as of 30 July 1992. The La Mesa Village population is broken down by family size in Table 4-2.

TABLE 4-2
LA MESA VILLAGE POPULATION DEMOGRAPHICS

Description	Sponsor	Dependent	Pop Total
Wife, No child	148	148	296
Wife, 1 child	260	520	780
Wife, 2 children	291	873	1,164
Wife, 3 children	102	408	510
Wife, 4 children	29	145	174
Wife, 5 children	3	18	21
Wife, 6 children	-	-	-
Wife, 7 children	1	8	9
Total	834	2,120	2,954

The Monterey Peninsula is a coastal area which receives 14 to 22 inches of rainfall each year. The possibility of a drought is strong in any given year with ten or fewer inches of rainfall constituting a dry year. Two dry years in a row uses up much of the water in the reservoirs, drawing heavily on the groundwater and depleting the reserve buffer of water in the aquifer. The water utility's deliveries have historically increased at an average rate of 3 percent per year. Current District projections indicate that demand will exceed the 22,000 acre feet of estimated water supply by the year 2000. The Peninsula is expected to have a serious water supply problem.[Ref. 27]

C. SOURCES OF DATA

1. Public Works Department

The Public Works Department at the Naval Postgraduate School provided monthly energy consumption figures through the Energy Audit Report. The data started with the fourth quarter FY 91 and went back three years to the second quarter FY 88. These Energy Audit Reports provided electricity and natural gas monthly consumption data for La Mesa Village.

2. Naval Energy and Environmental Support Activity

The Naval Energy and Environmental Support Activity in Port Hueneme, California provided Energy Audit Reports for La Mesa Village from the first quarter FY 88 back to the first quarter FY 84.

3. La Mesa Village Housing Office

The Housing Office at La Mesa Village provided water usage data for the period July 1992 back to January 1989. The Housing Office also listed energy related construction contracts completed over the last 15 years at La Mesa Village, although no dollar values could be associated with projects before 1985.

D. QUESTIONS

The Public Works Department was asked for utility consumption data.

The Housing Office at La Mesa Village was asked for building and population demographics. The Housing Office also provided water utility consumption data and energy related construction efforts.

The Naval Energy and Environmental Support Activity (NEESA) provided utility consumption data and explained how the 1985 utility baseline was established. NEESA also provided information on the Navy's progress at meeting its energy reduction goals.

Western Division, Naval Facilities Engineering Command in San Bruno, California provided information on new housing construction metering requirements.

V. ANALYSIS OF ALTERNATIVES

A. PRESENTATION OF THE PROBLEM

This thesis examines alternatives presented by the Deputy Assistant Secretary of Defense (Installations and Housing) in the Report to the Congress: Family Housing Metering Test to determine which provides the greatest economic incentive for family housing occupants to conserve utilities.

Before assessing the five utility reduction alternatives, two general issues concerning meter installation will be discussed. The first concerns individual versus master metering. The second is DoD's opposition to individual metering in family housing units. These discussions provide a foundation for comparing the five alternatives.

1. Individual versus Master Metering

a. Metering

Family housing units in DoD are currently master-metered. Government dwellings have a single meter to measure utilities (gas, electricity or water) consumed by the dwellings on the military base. Tenants who live in government housing receive no basic allowance for quarters (BAQ), but they pay no utility costs.

Individual metering, on the other hand, uses a separate meter for each utility for each dwelling. Each dwelling's utility consumption is read on a monthly basis for billing purposes.

Submetered dwellings use one meter for sections, buildings, floors or multiple units to supplement (or check) a master-meter. Submetering is essentially master-metering on a very small scale.

Of the five alternatives examined, four involve metering. The one alternative that the Deputy Assistant Secretary of Defense recommended to Congress was the only alternative that did not involve metering.

Table 5 - 1 outlines numerous studies conducted in the 1970s and 1980s concerning feedback effects on occupants and their utility consumption patterns. These studies indicate substantial quantity savings can be realized if accurate utility consumption data is presented to housing occupants. Appendix B contains more information on these studies.

TABLE 5 - 1
UTILITY STUDIES

Author	Utility	Year	Savings
Brown and Caldwell	Water	1984	20.0%
Nelson	Electricity	1981	20.0%
Seligman and Darley	Electricity	1977	10.5%
Winett, Kagel, Battalio, Winkler	Electricity	1978	12.0%
Craig and McCann	Electricity	1980	35.0%
Slavin, Wodarski, Blackburn	Electricity	1981	11.2%
Counihan and Nemtzow	Electricity	1979	26.0%
	Gas	1979	7.0%
Ritschard and Dickey	Fuel Oil	1974	50.0%

Not only do the studies in Table 5 - 1 indicate substantial savings by simply providing occupants with utility consumption data but Navy publications since 1977 identify metering and occupant feedback as critical to energy conservation programs.

Lt Walton's research in 1977 identified:

> A major one [problem of utility conservation] is the lack of verifiable feedback to the responsible managers for electricity consuming activities on an individual base. . . . Few electricity meters exist and they are situated to reveal the whole installation's consumption or that of several buildings or a large area within the base. As a result, the base utilities conservation manager has no ability to identify consumption in individual areas except through the use of engineering estimates. . . . Therefore, without the ability to identify consumption within the limits of lower echelon manager responsibility, an internal waster goes undetected because of another's conservation effort. [Ref. 4:pg 15]

The 1979 Energy-Related Attitudes of Navy Family Housing Residents study conducted by the Navy Personnel Research and Development Center in San Diego, concluded:

> The system variables having the greatest inhibiting effects on conservation included the construction and maintenance of housing and the *lack of information concerning cost and consumption*. System variables seen as having the greatest positive effect on conservation were those related to *information* and experience. From these results, it is apparent that an energy conservation program would best be of an educational nature, emphasizing development of proconservation attitudes and providing *information regarding energy-efficient practices, utility consumption, and costs*. (Emphasis added) [Ref. 13:pg 17]

The Navy publication most critical of Navy energy-conserving technology was the 1985 document Factors That

<u>Influence the Implementation of Energy-Saving Technologies at Naval Shore Facilities</u> [Ref. 11] published by the Naval Civil Engineering Laboratory in Port Hueneme, California. According to this report:

> Metering of energy use is strikingly inadequate at Naval shore facilities. Without meters, problem energy users can not be identified. Even conservative energy users (would-be energy savers) cannot determine the results of their efforts at improving efficiency without knowledge of this consumption. In fact, 50% of the military respondents to an energy questionnaire identified the inability to measure energy savings as a major obstacle to the adoption of new energy-saving technologies. [Ref. 11:pg 10]
>
> It is true that meters, in and of themselves, do not save energy. It is equally true, however that without the consumption information provided by meters, it is very difficult to assess the effects of energy conservation efforts and to determine whether these efforts are cost-effective. Even if metering were successfully installed, personnel may find little or no individual incentive to conserve because individual users cannot be identified or charged accordingly. [Ref. 11:pg 21]

With all the literature on the benefits of individual vice master metering, including Navy studies, DoD continues to insist on master metering for its military family housing units. Proponents of energy conservation strongly endorse a policy of removing hidden costs and thus charging consumers the full expense of supplying energy [Ref. 22:pg 1112].

A study conducted by Craig and McCann showed:

> master metered individuals were significantly more likely to engage in energy wasting behaviors. Specifically, they were more likely to leave the lights, television and air conditioner on when no one was directly using them. Consequently, this group is an important target for programs aimed at influencing consumption.

> While individuals living in single-metered dwellings should not be ignored, the price mechanism functions normally, providing feedback on consumption and more importantly a direct economic incentive to conserve.[Ref. 17:pg 165]

In a curious twist of events, Congress realized that direct economic incentives did promote utility conservation. The Public Utility Regulatory Policies Act of 1978 (PURPA) requires that each state's public utilities commission (PUC) consider prohibiting or restricting master metering of electric service in new buildings. By 1980, the PUCs of 31 states had banned or discouraged master metering. [Ref. 22:pg 1119]

One unique advantage of individual metering is identifying utility overhead. With the actual quantities of utilities that tenants consume each month, the Housing Administration can easily determine the amount of electricity lost due to line loss or the amount of gas or water lost due to leaking pipes and valves. With master metering, consistent utility loss would go undetected until a catastrophic event occurred, such as electrocution, fire, explosion or the undermining of a building foundation. Such an event would identify the nature of the utility loss.

b. Billing

With the individual metering scenario, billing is relatively simple. Dwelling meters are read on a monthly basis (gas, water and electricity) and the occupant is charged according to the established utility rate.

Under the master-metered or submetered scenario, utility costs can be allocated through a system known as RUBS - the Resident Utility Billing System. RUBS allocates space conditioning and electricity costs on a dwelling's square-foot basis. Although RUBS does not currently include water costs, water costs could be allocated based on a dwelling's population. Each occupant would pay a percentage of the total utility bill corresponding to their square footage (gas and electricity) and family size (water). [Ref. 22:pg 1114]

The RUBS allocation system is not as precise or equitable as using individual meters but is considerably less expensive to implement. With RUBS allocation, tenants still face an incentive problem of consuming more than they pay for as explained by Weimer and Vining. Weimer and Vining use the example of an evenly split restaurant bill to clarify why individuals in common property situations have an incentive to respond to marginal private cost rather than marginal social cost.

> Imagine that you are in a restaurant with a group of ten people who have agreed to split the bill evenly. If you were paying for your own tab, then you would not order the fancy dessert costing ten dollars unless you expected to get at least ten dollars' worth of value from eating it. But because the actual cost to you of the dessert will be one dollar (the average increase in your bill and for the bills of everyone else in the group), you would be rational (ignoring calories, your remaining stomach capacity, and social pressure) to consume it as long as it would give you at least one more dollar in value. You

> might continue ordering desserts until the value you placed on one more fell to one dollar. In other words, the individual's out-of-pocket cost for an additional dessert is the increment to his or her bill that is determined by the consumption averaged over the group. But this result is clearly inefficient because you and everyone else in the group could be made better off if you refrained from ordering the last dessert in return for a payment from the others of an amount between one dollar (your marginal private cost) and nine dollars (the difference between the marginal social cost and the marginal private cost that you perceive). Remember that the problem arises here because you have access to items on the menu at below their prices, which equal their marginal social costs. [Ref. 28:pg. 54]

The RUBS allocation system for submetered dwellings would be comparable to breaking the restaurant group in the previous example, into two groups of five people or smaller groups. With two groups of five people, your marginal private cost for the ten dollar dessert increases to two dollars instead of the previous one dollar. The remaining eight dollars are shared equally by four other people instead of the previous nine. The concept of submetering dwellings is to reduce the number of tenants on one utility bill vice all the tenants being on one utility bill as in the master metered dwellings.

2. Navy Opposition to Individual Metering

a. Installation

Most military family dwellings were constructed in multiple units without considering individual metering. Utilities were usually installed in the most economical method, for a master-metering scheme. Isolating utilities for each dwelling and installing individual meters would be a monumental undertaking.

> The total implementation of a DoD-wide metering program is estimated to require between 5 and 6 years. The estimated cost of metering the remaining 300,000-odd units of DoD housing in the 50 states and U.S. possessions is $415,177,000 in 1981 dollars. [Ref. 3:pg 7-8]

DoD responded to Congress' proposal to meter and charge occupants for excess consumption to the literal extent of the legislation and not to the intent of the Congressional legislation. Responding to the proposed legislation, DoD estimated it would cost $415 Million to individually meter all remaining family housing dwellings. If DoD had responded to the Congressional intention, DoD would have proposed to individually meter dwellings where economically feasible. They would submeter buildings where individual metering was prohibitively costly. Then occupants could be billed according to RUBS.

Using La Mesa Village as an example, Table 5 - 2 compares the costs of individually metering and submetering buildings. It would cost $196,560 to install 702 individual meters in the 117 duplex units (Building 2).

$$\left(\frac{2\ Units}{Building}\right)\left(\frac{3\ meters}{Unit}\right)(117\ Buildings)\left(\frac{\$280}{meter}\right)=\$196,560$$

It would cost $98,280 to install 351 submeters in the same 117 duplex units.

$$\left(\frac{3\ meters}{Building}\right)(117\ Buildings)\left(\frac{\$280}{meter}\right)=\$98,280$$

TABLE 5 - 2
COSTS OF INDIVIDUALLY VS SUBMETERED DWELLINGS

Units/Bldg	# of Bldg	Metering Costs (meters) Individual	Submeter
1	80	$ 67,200 (240)	$ 67,200 (240)
2	117	$196,560 (702)	$ 98,280 (351)
3	17	$ 42,840 (153)	$ 14,280 (51)
4	72	$241,920 (864)	$ 60,480 (216)
5	12	$ 50,400 (180)	$ 10,080 (36)
6	18	$ 90,720 (324)	$ 15,120 (54)
7	1	$ 5,880 (21)	$ 840 (3)
8	5	$ 33,600 (120)	$ 4,200 (15)
9	-	-	-
10	1	$ 8,400 (30)	$ 840 (3)
	323	$737,520 (2634)	$271,320 (969)

Based on the installation of 3 meters (gas, water and electricity)

Based on the average installation cost of $280 per meter

In Table 5 - 2, submetering all buildings at La Mesa Village appears to cost a third what it would cost to individually meter dwellings. This assumes that the average installation cost of each meter is $280. This greatly simplifies the calculation for individual meter installation in the larger dwellings (4 or more dwellings) which the Family Housing Metering Test showed could cost as much as $35,000. If this same ratio, 0.3678 ($271,320 / $737,520) is applied to the DoD wide estimate of $415 Million it would appear that all

DoD family housing buildings could be submetered for approximately $153 Million, a figure Congress may have been willing to fund.

b. Personnel Loss

The Report to the Congress: Family Housing Metering Test argues:

> Any change or penalty for military occupants for whom all energy was previously included in the rent will have definite morale impact with accompanying personnel retention considerations. . . . As a measure of the possible cost impact, an attrition of 1/4 of one percent of career military personnel as a result of a metering program would cost $118,000,000 for replacement of these experienced midrange management personnel.[Ref. 3:pg 7-25]

DoD also estimates that 15 percent of the military housing population under the proposed legislation would exceed a "norm" allowance and be required to pay for excess consumed utilities. The cost of utilities to occupants and its subsequent effect on personnel retention will be discussed under each alternative.

c. Monthly Meter Readings

(1) Personnel Cost

It is estimated that DoD would need an additional 487 employees to read meters at the 424 DoD activities. This would cost $13 Million in FY 1987 dollars. [Ref. 3:3-42] Included in the $32 Million annual cost of metering is not only the meter reader salaries but meter maintenance and accounting necessary for billing each family housing occupant.

(2) Norm Calculations

The norm criteria developed during the DoD metering test were set to provide family housing residents in military housing with a quality of life comparable to military families living in civilian housing. Still, the norm does not quantify or model the complex aspects of human behavior, nor does it provide a means of comparing military family life with life in the civilian sector. [Ref. 3:pg 7-10]

It is commendable that the Deputy Assistant Secretary of Defense insists on preserving equity between the quality of life for military families living in military housing units and those living in rental housing. However, the quality of life in the two housing environments cannot be compared when two different incentives for the conservation of utilities are in effect and may not have been equal to begin with.

The tenant living in rental housing has access to large quantities of utilities, provided he pays for all utilities consumed. The amount of utilities he consumes is proportional to the value he places on the utilities. The tenant living in government quarters, under any alternative except number two, is subject to an educational program and a military housing community atmosphere. This atmosphere implies that a "good tenant" voluntarily sacrifices or controls his consumption in order to conserve government utility costs. In order for the Housing Administration to realize utility savings, tenants must voluntarily forego the consumption of desired utilities, this implies the quality of life in military housing decreases relative to the quality of life in rental housing.

The complex utility norm is another instance where DoD has taken Congressional intent to an extreme. The algorithm to calculate a single utility norm for one housing unit over a 30-day period involves 289 pieces of data and entails 21 calculations [Ref. 3:pg 6-3]. The norm calculation for each housing location could be simplified by dividing up the quantity of utilities consumed over the housing population. Electricity and gas norms for each dwelling could be allocated by number of bedrooms (See Table 5 - 3) with water allocated per person. Appendix B shows an example norm calculation for La Mesa Village.

TABLE 5 - 3
EXAMPLE NORMS FOR LA MESA VILLAGE

	Electricity	Gas
2 Bedrooms	475 Kwhr/month	6900 KBtu/month
3 Bedrooms	605 Kwhr/month	7950 KBtu/month
4 Bedrooms	670 Kwhr/month	9150 KBtu/month

Water set at 80 gallons per person per day.

Using generic norms places utility norms on the same quality of life basis as basic allowance for quarters (BAQ) and basic allowance of subsistence (BAS). How this simplified norm affects tenants will be discussed under each alternative.

(3) Billing

Eliminating the 300 variable norm calculations and using the generic utility allowances derived in Appendix B, would simplify monthly billing calculations. They could be maintained and processed on PC computers using almost any spreadsheet program.

Buildings that are submetered could be billed in two ways. Each dwelling could be billed directly for its proportional share of gas and electricity based on its proportionate square footage. The water bill would be apportioned to each dwelling according to the number of people in residence. The second method would assign a utility representative from each building to fairly apportion the monthly utility bill among the building tenants. With the second method, each building is billed strictly on the utility meter readings and the tenants themselves would work out what they considered a fair distribution of utility costs.

Possible billing procedures will be addressed under the implementation section of each alternative.

d. Service Calls

With occupants paying utility costs, occupant education and increased occupant generated maintenance service calls are estimated to cost over $23,000,000 annually.

This estimated $23 Million annual education and service cost exists regardless of the metering alternative chosen. Under the metering alternatives with no education or utility costs to occupants, this $23 Million annual cost is being lost in other ways. When occupants receive no education and do not pay any utility bills, the $23 Million annual savings in education and service calls is being lost by the Housing Administration through drafty houses, leaking faucets, and inefficient household appliances.

B. ALTERNATIVE I: METER / BILLING OF EXCESS CONSUMPTION

1. Description

> This alternative is the most literal interpretation of the congressional direction provided in 1977. Each housing unit would be individually metered and consumption data collected monthly. DoD would develop a norm (ceiling) which would serve as a standard describing its interpretation of the maximum amount of each utility a given family should utilize considering family size. The consumption data would then be compared to the norm and the occupant would be billed monthly for any utility consumed above the norm.[Ref. 3:pg 8-1]

2. Economic Analysis

a. *Theory*

This alternative is essentially a failed market mechanism with a punitive measure as an attempted correction. The occupant incurs a cost for total utility consumption in excess of the utility allowance. The Report to the Congress states,

> It is projected that the feedback received by 85 percent of the residents would reduce that group's consumption by 4 percent. The consumption attributed to excess usage by the 15 percent above the norm is projected to drop far enough that an additional 2 percent of the total family housing energy would be saved. Not all excessive users would drop below the norm because of the lack of sufficient incentive to change their lifestyle. [Ref. 3:pg 8-2]

From an economic viewpoint, the tenant has no incentive to conserve. If utilities are a limited resource which usually involve competition (cost), then we find ourself in an unusual market where the consumer receives a free good up to a specific limit. The only incentive for consumers to reduce consumption of a free good is either that the consumer tires of the free good and voluntarily changes his consumption behavior or external factors like advertising, propaganda, and eduction cause a sense of guilt when the occupant consumes more of the free good than necessary for basic comfort.

The family housing metering test estimated that occupants consuming below the utility allowances would decrease their consumption an additional 4 percent simply because they receive information on their utility consumption. In the present non-metered housing environment, occupants do not have individual consumption data. The concerned occupant without utility use information may wash his car quarterly and water his lawn every other week during the summer. With accurate individual utility use information, more occupants may feel they are doing their part for conservation if they do not exceed their allowance. Occupants may increase their consumption up to their allowance level. Under this scenario, utility usage at La Mesa Village would increase with most occupants consuming their allowance. The only reward for under consuming utilities is good feelings for conserving the world's natural resources.

b. Example

Using the norms established in Appendix C, this alternative will be illustrated using a family of four living in a 3 bedroom house. According to Appendix C, this family receives the following monthly utility norm:

	Norm	Unit Cost	Cost
Electricity:	605 Kwhr/month	$0.064/Kwhr	$ 38.72
Gas :	7950 KBtu/month	$0.014/KBtu	$111.30
Water :	9600 Gals/month	$0.003/Gal	$ 28.80
		Total	$178.82

Assuming our example family consumes 15 percent more of each utility, and pays for the excess at the specified unit cost, the monthly utility bill would be:

	Usage	Norm	Delta	Cost
Electricity:	695.7 Kwhr	605.0 Kwhr	90.7 Kwhr	$ 5.80
Gas :	9142.5 KBtu	7950.0 KBtu	1192.5 KBtu	$16.69
Water :	11040.0 Gals	9600.0 Gals	1440.0 Gals	$ 4.32
			Total	$26.81

The family housing occupant might perceive that the $26.81 excess utility consumption payment is the total monthly utility bill. While this alternative provides appropriate conservation incentives on the margin by requiring residents to pay 100 percent of their above norm utility consumption, military families do not typically think marginally or in terms of excess costs. Military families do not discuss monthly food bills as being, "$150 in excess of BAS". Families think of housing rental costs and food in terms of total monthly costs. Rent is described as $700 a month plus utilities, not $200 a month plus utilities in excess of BAQ.

When a military family receives an allowance for rent or food, the money becomes part of the total family financial resource pool. Expenditures on rent or food then draw from the entire family financial resource pool with full economic impact of its cost on alternative economic choices.

3. Implementation

a. Billing

Under Alternative I, military housing occupants would receive a monthly bill for utilities consumed in excess of an established norm. With a generic norm similar to BAQ, utility billings would be a trivial process of comparing the monthly meter reading with the norm and charging the occupant a preset rate for his excess utilities.

With such a simplified billing process, most existing housing offices could generate and monitor utility bills with existing computer assets and spreadsheet programs like Lotus 1-2-3 or Quattro Pro. The computer billing program would be based on total utility consumption rather than individual utility consumption. For example, a tenant consuming more electricity and water than the norm, but less gas, could end up paying nothing on a total utility cost basis.

	Usage	Norm	Delta	Cost
Electricity:	705 Kwhr	605 Kwhr	100 Kwhr	$ 6.40
Gas :	7200 KBtu	7950 KBtu	(750) KBtu	($10.50)
Water :	10800 Gals	9600 Gals	1200 Gals	$ 3.60
			Total	($ 0.50)
			Tenant's Bill	$ 0.00

b. Effect on Tenants

In passing Public Law 95-82, Congress intended to change utility costs above a norm for military housing occupants. The desired effect was lowering utility consumption below the norm. Congress never intended to evict military housing occupants for utility consumption in excess of the norm.

The example in V.B.2.b showed that utility costs up to the norm, which amounted to $178.82, were paid by DoD. This is a utility subsidy by DoD to all military housing occupants. It is not provided to military members living in rental housing. In the example, the resident who over consumes by 15 percent is only assessed a charge of $26.81.

This minuscule charge for such a large utility consumption would have a positive effect on the morale of the military housing occupant if their only other option is to move out of military housing into the rental housing market.

In the rental market, occupants bear the full utility cost burden, $205.63.

Under this alternative, billing errors are a significant concern to military housing tenants. These errors are not self-correcting as they are in the rental housing community.

> If the civilian consumer is erroneously overcharged one month, a presumably correct meter reading the next month will yield an offsetting undercharge. However, military members under the proposed system would be "starting with a clean slate" each month, because their consumption would be measured against an absolute usage norm for each given month. Without cash credits for consumption below the monthly norm, an undetected erroneous overcharge would be irretrievably forfeited. [Ref. 3:pg 6-5]

4. Pros and Cons

a. Pros

Metering with billing for excess utility consumption has two advantages: this alternative would be transparent to the majority of military housing occupants (85%) who are usually below the norm and cash receipts would only be expected from 15 percent of the military housing occupants, implying that the administrative and accounting burden on the Housing Administration would be minimal.

b. Cons

There are four disadvantages of this alternative. First, there is no incentive for military housing occupants already below the norm to conserve further. Residents may view the norm as an allowance or right and increase consumption up to the norm. Furthermore, it is financially prudent for large utility consumers to live in military housing because they receive a utility subsidy up to the norm.

The second disadvantage is that all occupants must receive consumption information to evaluate whether they are exceeding the norm and to stimulate utility consumption behavior modification. Costs of metering, meter reading, and education cannot be reduced by only providing information to the 15 percent that over consume utilities because under consumers may increase their consumption until they get a bill.

The third disadvantage is that an ongoing educational program is required to incentivise residents to conserve utilities through guilt. Even with an established norm, money must be continually spent on conservation education to entice all occupants to conserve further. This educational process has the potential of costing more than the realized savings of the conservation efforts.

The fourth disadvantage is that billing errors cannot be corrected in future months under this punitive system. Each resident's utility usage is wiped clean after comparing it with the utility norm.

C. ALTERNATIVE II: METER WITH FULL PAYMENT

1. Description

Metering with full payment is identical to the method used by public utilities to sell energy to individual home residents. Each family unit would be individually metered and the consumption data collected periodically, typically monthly.

Every occupant would then be billed for all the energy consumed during the billing period. The rates charged for the energy could be the adjusted cost to the base. An added fee based on actual cost could be charged for late or delinquent payment. [Ref. 3:pg 8-5]

2. Economic Analysis

a. Theory

This is the only one of the five alternatives analyzed that has a functional market mechanism; the purchaser of the utilities is also the consumer. With full payment for utilities, tenants in military housing and tenants in rental housing would both face the payments and economic incentives to conserve. However, requiring military housing occupants to pay for utilities on a monthly basis would have an immediate impact. An occupant living in government quarters and paying for utilities would see himself at a financial disadvantage compared to military members living in rental housing if he lost his BAQ and VHA allowances. Housing occupants would likely expect a rent rollback to compensate for the added utility bill.

Full utility payment without some form of utility allowance would place a financial burden on tenants living in military housing. Living in government quarters would be less financially prudent. The remainder of the analysis for this alternative assumes that rents are rolled back to compensate military housing occupants for their newly acquired responsibility for utility bills.

Counihan and Nemtzow discussed the economic incentives that motivate renters to adopt conservation measures.

> If a tenant is to make any financial gain from a conservation investment in an individually metered building, it must be from savings on utility expenses. The net result is that only the most inexpensive or portable conservation measures will attract a renter's interest. Examples are weatherstripping, caulking, shower flow restrictors, water heater blankets, and insulating drapes or window coverings. Tenants may be reluctant to invest in such measures if they doubt their future value; drapes, for example, might not fit the windows in the next unit. [Ref. 22:pg 1120]

The tenant would realize financial gains by modifying his behavior to lower his monthly utility bill. The landlord (the government in this case) would realize lower operating costs by improving utility efficiencies in the unit like, fireplace dampers, high efficiency furnaces, water flow restrictors, high efficiency refrigerators, electronic ignition for gas appliances and units retrofitted to utilize fluorescent lighting. Full utility payment by tenants highlights a distinction between the tenant's and the landlord's conservation responsibilities. The tenant focuses his conservation effort on his consumption behavior. The value he places on the utilities would be reflected in the monthly utilities he purchases. The landlord focuses his conservation effort on the building's utility efficiency. By improving the building's utility efficiency, the landlord (the government in this case) could lower the utilities rent rollback because the utility costs are lower in efficient buildings.

b. *Example*

This alternative will be illustrated with the same example used for Alternative I. Using the same norms, our family of four living in a 3 bedroom unit would receive a $178.82 utility allowance.

	Norm	Unit Cost	Cost
Electricity:	605 Kwhr/month	$0.064/Kwhr	$ 38.72
Gas :	7950 KBtu/month	$0.014/KBtu	$111.30
Water :	9600 Gals/month	$0.003/Gal	$ 28.80
		Total	$178.82

The occupant consuming his entire utility allowance would pay $178.82 per month. Tenants consuming less would realize the direct economic incentive of lower utility bills and more funds to spend on other goods. Those tenants who place a high value on utilities could consume and pay for more utilities. They would spend more than their utility allowance. Consequently, they would have less money for other goods.

This situation is similar to current BAQ and VHA allowances. Military service members who choose to live in rental housing receive BAQ and VHA to cover rent and utility costs. Tenants who spend less than their BAQ and VHA rates on rent and utilities have excess funds available to spend on other goods. Tenants whose monthly rent and utilities exceed their BAQ and VHA rates end up spending part of their monthly salary. Hence, they have less money available for other goods.

The norm in Appendix C was established by distributing the current La Mesa Village utility consumption over the housing population. The norm calculation method provides utility norms comparable to utilities consumed in rental dwellings. Utility norms could be gradually reduced to allow the government to reach some preset utility conservation goal. Let's say 65 percent of La Mesa Village residents are 6 percent below their norm, 20 percent of the residents are 12 percent below their norm and 15 percent of the residents are 15 percent above their norm. To encourage utility conservation, the norms could be reduced by 10 percent which would have the following impact on tenants and the government.

	Norm	Unit Cost	Cost	10% Red	Cost
Elec :	605 Kwhr	$0.064	$ 38.72	544 Kwhr	$ 34.82
Gas :	7950 Kbtu	$0.014	$111.30	7155 KBtu	$100.17
Water:	9600 Gals	$0.003	$ 28.80	8640 Gals	$ 25.92
	Total		$178.82		$160.91

This example shows that the resident's utility allowance drops from $178.82 to $160.91 if the government's goal is a 10 percent utility reduction. This has a direct economic impact on the tenant if he wishes to consume the same amount of utilities as before the utility reduction. This utility reduction would have an immediate impact on government funding since the government would realize the $17.91 monthly savings in the utility allowance.

The opposite would also become apparent when utility rates increase. An increase in utility rates by the utility companies would have to be reflected in each tenant's utility allowance if the utility allowance is to remain a fair economic incentive to tenants. Periodically reevaluating the utility allowance would be similar to periodically reevaluating rental cost allowances in the civilian community. Through a periodic questionnaire of military member's living costs in rental dwellings, DoD readjusts the military member's BAQ and VHA rates throughout the United States based on the local community's cost of living.

3. Implementation

a. Billing

The billing process under this alternative would be no more complicated than under Alternative I. The only difference is that all military housing occupants would have to pay monthly utility bills. The Housing Administration would require an accounting department large enough to handle the monthly billing and collection process.

The simplest billing procedure allows the local utility companies to read the meters and bill the residents. In the case of submetered building complexes, one resident could receive the utility bill for the building and collect payments from the remaining tenants through an apportionment system as described previously.

The Deputy Assistant Secretary of Defense decided not to have local utility companies bill military tenants directly, for three reasons:

> First, hundreds of utility companies would be involved because most housing units have at least two sources of energy, for example, electricity and gas. Secondly, tremendous modifications on a large scale would be required to incorporate the norm concept into all the existing billing systems, and it is doubtful that any utility companies would agree to make the changes and assume responsibility for the metering. Thirdly, it is also anticipated that extensive, costly upgrading of utility distribution systems for housing units would be required to meet a variety of State and local standards before utility companies would accept maintenance responsibility. [Ref. 3:pg 3-47]

b. Effect on Tenants

The obvious effect that full utility payment has on military housing tenants is that tenants will be aware of their utility usage on a monthly basis. This fact alone should stimulate a reduction in utility usage as pointed out at the beginning of this chapter.

The military service member would now have to assess whether government quarters or rental housing is the financially prudent choice. The choices are: living in government quarters, receiving no BAQ and VHA, receiving a utility allowance and paying a monthly utility bill or living in rental housing, receiving BAQ and VHA but paying all monthly rental and utility bills. This choice now makes it more difficult for utility wasters. They will financially suffer under either choice unless they modify their utility use. For conservation minded military members, this would be further incentive to live in government quarters. This choice would financially benefit the military member because he pays less for his monthly utility bill than he receives in his monthly utility allowance.

4. Pros and Cons

a. *Pros*

As previously mentioned, the greatest benefit from full utility payment is the direct economic incentive tenants have to reduce utility consumption. As the tenant modifies his utility use, his utility bill is directly reduced and he can purchase other goods with the money he would have spent on utilities.

The remaining advantages all apply to the landlord (government). The first three advantages for the landlord involve utility cost decreases due to adjustments in utility allowances and education. More specifically, the government could lower the utility allowance for each tenant as building efficiency improves. This would lower the monthly government utility costs.

In addition, now that a utility allowance is provided to each tenant, the government's utility costs do not vary with the tenant's consumption. The tenant can over consume utilities as much as he wants, as long as he pays for the utilities.

The third advantage is that this alternative does not require any substantial government educational effort. Once an allowance is provided to the tenant, he is free to choose whatever lifestyle is within his financial means. The financially prudent utility consumer will realize that modifying his utility usage has economic benefits and he will implement the cheapest and most portable conservation measures. If the government spent money on an educational conservation program aimed at persuading tenants to reduce utility consumption, they would not receive any financial benefit. The government's utility cost is independent of the tenant's utility usage.

The final advantage involves the Housing Administration. Providing a utility allowance to each housing tenant would remove military housing utility funding from the Housing Administration and give it to the tenants. In effect, Housing would lose the single pot of money they currently receive from Congress and would have to collect the money from individual tenants. This would encourage the Housing

Administration to strive for 100 percent occupancy in government quarters to ensure that fixed utility costs, costs occurring regardless of utility use, and recurring housing overhead costs were effectively covered each month. The American taxpayer benefits in this case. By encouraging 100 percent occupancy of government quarters, Congress can reduce BAQ and VHA appropriations. Fewer military members would have the option of choosing rental housing over government quarters.

b. Cons

The three disadvantages of full utility payments are fairly minor relative to the potential benefits. One disadvantage is that another military pay allowance would have to be authorized by Congress. If Congress was serious in its attempt to control DoD utility costs this would seem to be a small price to pay. Implementing and distributing utility allowances would be no more complex than the existing BAQ and VHA allowances.

The second disadvantage is the need for an accounting system to bill and collect monthly utility costs. The actual accounting procedures are rather straight forward. The down side is the need for an increased Housing Administration staff to handle the new accounting responsibilities.

The last disadvantage, from the Housing Administration's viewpoint, is Housing's loss of control over utility funding. Housing could only pay its utility costs by collecting money from each tenant. From the perspective of the taxpayer, this is as an advantage, as described previously.

D. ALTERNATIVE III: METER WITH FEEDBACK ONLY

1. Description

This alternative emphasizes the principle of consumption data feedback as a method to promote energy conservation. In this instance the feedback provided to each family is the amount of energy consumed by either the family or a major portion of the family housing complex. In the other instance it will be necessary to meter each housing unit. In the latter case master meters will be installed as required to record the total energy consumed in a contiguous complex which may have anywhere from 2 to 500 units. In either situation, the meters would need to be read periodically and statements sent to each residence. The statement would show consumption for the billing period and possibly a comparison with the previous year's identical billing period. A norm would not be used. The information could be presented not only in energy consumption figures such as Kwh and Btu but also in dollars. No bill would be sent for any energy consumed. A supporting educational program would aid the resident in the interpretation of the feedback and establish means to conserve energy. [Ref. 3:pg 8-7]

2. Economic Analysis

a. *Theory*

Once again we find ourselves analyzing an alternative with a failed market mechanism. The utility purchaser (government) is not the same entity as the utility consumer (military member). Economically, metering with feedback only is the worst of the five alternatives for encouraging utility conservation. In both its description and analysis of this alternative, the Report to the Congress: Military Housing Metering Test never mentioned any consequences to military tenants that ignore the feedback and continue to consume excess utilities. Punishment for over consumption in any form is never mentioned. Consumption modification occurs through an educational program.

Whether housing units are individually metered with individual feedback or master metered with group effort feedback, there is simply no economic incentive for tenants to reduce utility consumption. The only conservation effort metering with feedback provides is an educational program designed to modify tenants' behavior based on guilt for over consumption.

Clive Seligman and John Darley [Ref. 20] conducted a residential energy consumption study in 1977 that provided informational feedback only to 29 physically identical three-bedroom homes. Their study indicated that a 10.5 percent electricity reduction was achieved during the three week feedback period. Seligman and Darley admit that by soliciting volunteers to participate in their study they may have started with a biased population sample. In line with predictions derived from either cognitive dissonance theory or attribution theory, participants probably developed attitudes favorable to conservation which helped to sustain the motivation to conserve electricity during this three week study.

> In the present study, the level of energy conservation obtained was unrelated to the initial level of energy use. This suggests that energy conservation campaigns need not be aimed solely at the relatively higher energy consumers; lower users are also capable of further conservation. But this finding also may be a result of the particular nature of the feedback, which was organized in terms of deviations from the person's own past energy usage; moderate energy users were as affected by this kind of feedback as were high users. High-energy consumers might be more affected by feedback that promoted comparisons with other users.
>
> One of the most urgent questions that arise concerning consumption feedback is its effectiveness over time. For practical application of the feedback technique, its efficacy over long periods of time would need to be demonstrated. [Ref. 20:pg 367]

Without using some form of utility norm, Seligman and Darley raise three interesting questions. First, what sort of yardstick would be used for comparison purposes? If each tenant's previous years consumption is used as the conservation reference point, then weather differences would cause a great deal of confusion. If last winter was particularly severe and this winter is quite mild, utility comparisons may be quite difficult.

The second question Seligman and Darley raise is: how much effort at conservation is considered good? Their study showed that low energy consumers as well as the high energy consumers were capable of conserving utilities. With continuous utility feedback, tenants may feel that they are being asked to continually sacrifice a moderate lifestyle for a lifestyle of deprivation in order to show continued utility savings during their residence in government quarters. This obviously is not what the Secretary of Defense had in mind when he insisted that the quality of life for military housing and rental housing should be comparable. The Secretary of Defense does not believe that military members and their families should be subject to restrictions more severe than those placed on private citizens nor that they should lose basic entitlements under the guise of energy conservation. [Ref. 3:pg ii]

The third question Seligman and Darley raise is how effective a conservation program would be for an uninspired housing population subjected to continuous conservation propaganda? Seligman and Darley's study lasted only three weeks and involved volunteers. A captive audience subjected to a continual barrage of utility conservation propaganda may rapidly lose interest when they realize that there are no economic or punitive consequences for poor performance.

Winett, Kagel, Battalio and Winkler obtained some startling results when they compared the electricity consumption of three groups of Texas volunteers. Two groups received a monetary reward based on their conservation effort while the third group received utility usage feedback information only.

> Overall, the results indicated that only the high rebate system yielded substantial reductions in electricity use during the entire experimental period. A low rebate system was only marginally effective, and weekly feedback and information were ineffective in curtailing electricity use. In fact, information given alone may increase use. [Ref. 14:pg 78]

b. Example

It is not possible to use a numerical example to illustrate metering with feedback only. There is no provision for a utility norm, utility allowance or payments by tenants for utility consumption under this alternative. Tenants could theoretically consume unlimited quantities of utilities for which the government would pay.

3. Implementing

Metering with feedback only has no billing procedures since there is no provision for tenants to pay utility bills. Metering with feedback only would probably have a modest impact on military tenants. Passive, low cost conservation measures would probably be adopted (e.g., low flow shower heads, fluorescent lighting, caulking or use of a microwave oven rather than the gas stove). Active conservation measures requiring some tenant participation to realize utility savings would be very difficult to obtain without either a reward or punishment based on consumption behavior.

This system was attempted in a short term field trial in family housing at Pensacola, Florida. A 5 to 6 percent savings in electricity was realized. This Energy Conservation Advocacy Program included:

- Face-to-face coaching regarding energy saving methods and practices
- Conservation advocacy by a person seen as expert and concerned about the quality of the tenant's lives
- Active participation in the learning and change process by all family members from school age up
- Identification with neighborhood and community
- Communication of community social norms regarding energy consumption
- Group (neighborhood and community) energy consumption feedback on a regular basis

The program was designed to cover one complete year. It is repeated in the same format in succeeding years. This program is a never ending educational process requiring face-to-face contact between military housing residents and the housing energy advocate.

An educational program would be beneficial for passive conservation measures (engineering measures). Tenants could eventually resent active conservation measures requiring the tenants' cooperation to modifying utility consumption behavior. Repetitive reminders to conserve eventually lose their appeal when the consumer has no economic incentive to change his behavior. Relying on guilt to incentivise conservation can only instill resentment and anger in the consumer since he has no idea how low his consumption should be before the 'guilt-trip' is turned off.

4. Pros and Cons

a. Pros

The only advantage this alternative has over the previous alternatives is that there is no cost to implement an accounting system for billing and collecting monthly utility payments.

b. Cons

Of the six disadvantages, the first three deal with the tenants' perception of this alternative. First, without a market mechanism, there is no economic incentive to change the tenants' consumption pattern. Studies have showed only limited success in utility reductions when tenants are asked to sacrifice their lifestyle for no apparent economic benefit. Second, without a utility measurement standard it is very difficult to determine what level of utility conservation is sufficient or conversely, inadequate. Third, with constant exposure to utility conservation propaganda, a high level of tenant enthusiasm and participation may be difficult to sustain.

The next two disadvantages deal with the utility conservation educational program. First, as with Alternative I, the primary motivation for the educational effort is guilt. Reliance on guilt to obtain utility reductions can only foster resentment and lack of interest in the conservation program. Second, the educational program has an unlimited potential to consume funding. Unlimited money could be thrown at the educational program. As Seligman and Darley said, "instrumenting feedback will be a costly process, and it is necessary to know when that is cost effective [Ref. 20:pg 367]."

The final disadvantage is that the entire utility savings is generated from the educational program. When a base faces financial cutbacks, educational and training programs are usually the first to be cut. Any reduction in the level of funding for the military housing utility education and feedback program would be viewed by the tenants as a lack of commitment to utility conservation by higher authority.

E. ALTERNATIVE IV: BUILDING AND EQUIPMENT IMPROVEMENT

1. Description

Building and equipment improvement consists of two parts. One involves altering the characteristics of all DoD family housing buildings and the other provides for the development of a new source of energy. The former program involves three major retrofit opportunities. It is proposed that the retrofitting concentrate on reducing the requirement for space heating and cooling, which represents 60 percent of the demand in a typical home. Two projects, adding insulation throughout and installing thermal blanketing on windows, would reduce the heat loss or gain through the ceilings, walls, floors, and windows. The third project would concentrate on reducing heating or cooling loads by reducing air infiltration through unsealed windows, doors, etc. Additional projects may include the installation of dual element temperature limiting thermostats and insulation blankets on water heaters, solar shading, duct insulation, etc. The latter program provides for the conversion of electric or natural gas DHW to solar heat in 50,000 southern units which would save approximately 150,000 equivalent barrels of oil each year. [Ref. 3:pg 8-11]

2. Economic Analysis

a. Theory

Building and equipment improvement is the third example of a failed market mechanism for encouraging utility conservation. Of the five alternatives analyzed, building and equipment improvement is the only alternative that does not attempt to modify the tenants' consumption behavior. The savings in utility costs would be derived specifically from engineering improvements in existing buildings.

The Deputy Assistant Secretary of Defense fails to point out in the Report to the Congress that building and equipment improvements should be an integral part the other four alternatives, not a separate alternative. Building and equipment improvements are the landlords' responsibility; modifying utility consumption is the tenants' responsibility. An effective utility conservation program would incorporate both landlord and tenant contributions toward utility cost reductions.

Investments in building and equipment face major obstacles. The tenant is not willing to improve property that is not his own. The landlord is not willing to invest in improvements that have a payback period greater than three or four years. DoD recognizes its responsibility for efficiency improvements in military housing. The Energy Conservation Investment Program (ECIP) only requires a 6 year or less payback period on building and equipment improvements. Once an improvement is approved and funded by DoD, the lack of accurate metering prohibits verification or analysis of the resulting energy savings. The lack of accurate metering makes it difficult to evaluate efficiency improvements. In addition, energy wasters may negate the utility savings in master metered housing.

As an example, the 15 energy conservation measures listed below have been implemented at La Mesa Village between 1975 and 1992.

TABLE 5 - 3
ENERGY CONSERVATION MEASURES AT LA MESA VILLAGE

Install fluorescent lights
Jan 1992 $349,414

Install electronic ignition to gas heating furnaces
Oct 1991 $140,887

Replace casement windows with double pane windows in Wherry housing
Aug 1986 $1,080,514

Install water heater insulation jackets
Sep 1985

Install hot water control valves on 250 gallon hot water tanks '69 housing
Jun 1985

Insulate hot water lines during a repair project in '69 housing
Dec 1983

Insulate the walls during siding repair project in '65 housing
Sep 1983

Install night set-back thermostats
Mar 1984

Replace gas line piping
Aug 1980

Insulate attics
Oct 1978

Install forced air heating systems in Wherry housing
Jan 1979

Replace hot and cold water piping in Wherry housing
May 1978

Install water saving showerheads
Sep 1977

Repair forced air heating systems in Capehart housing
Apr 1976

Replace ceiling insulation in Wherry housing
Oct 1975

Specific savings due to each energy improvement cannot be measured or identified. The Energy Audit Report from NEESA documents a 19.15 percent reduction in electricity and natural gas consumption from 1975 to 1985 for La Mesa Village, based on 1975 utility consumption rates. The specific contributions of energy conservation measures completed during this period cannot be evaluated.

From 1985 through 1991, La Mesa Village has realized an averaged total 6.17 percent reduction in electricity and natural gas consumption based on 1985 utility consumption rates. The cumulative 1985 utility baseline is 847,060 Mbtu for La Mesa Village for the period 1985 to 1991.

794,737 MBtu were actually consumed during that period. Approximately 80 percent of La Mesa Village utilities are natural gas. The remaining 20 percent is electricity. This would suggest that in seven years La Mesa Village has saved 52,323 MBtu of energy over its 1985 energy baseline. This equates to approximately $524,282 over seven years. The lack of individual metering does not allow these savings to be discounted in any way. It is impossible to distribute these savings among the energy conservation programs and thereby assign specific savings to each year.

$$(52,323\ MBtu)(80\ percent)\left(\frac{\$6.83}{MBtu}\right)=\$285,893$$

$$(52,323\ MBtu)(20\ percent)\left(\frac{Mwhr}{3.413\ MBtu}\right)\left(\frac{\$77.75}{Mwhr}\right)=\$238,389$$

The three most recent conservation measures at La Mesa Village cost $1,570,815. This implies that three times more money has been spent on energy improvements than has been received in reduced operating costs.

Separate metering of housing units in the rental market removes the direct incentive for landlords to improve their buildings and equipment. The utility bill is passed on to the tenant (though these may be an indirect effect if landlords' can increase rents). In military housing with a utility allowance (Alternative II), utility improvements would lower utility allowances, providing a direct incentive to the landlord to improve the utility efficiency of military dwellings. With no individual meters and landlord utility payment, savings from landlord utility improvements must be large enough to outweigh the energy wasters efforts.

Building and equipment improvement is a half-measure in the utility conservation program. Counihan and Nemtzow recognized that both landlords and tenants need to participate in utility conservation in master metered dwellings.

> Tenants control much of the pattern of energy use, while landlords establish the efficiency of consumption. Both parties therefore affect the quantity of total use, but only one party (landlord) pays the utility bill. [Ref. 22:pg 1104]

If the landlord takes responsibility for building and equipment improvements in a master-metered dwelling, there is no economic incentive for the tenant to conserve. Utility consumption may actually increase if tenants rationalize that greater utility efficiency allows a more luxurious lifestyle.

3. Pros and Cons

a. Pros

The first advantage of building and equipment improvements is this alternative's relatively low initial cost relative to the other four alternatives. This is the only alternative not requiring extensive costs for metering, education and feedback, making this alternative initially the cheapest alternative.

The second advantage of building and equipment improvement is that the landlord's improvements are totally independent of the tenant's utility consumption behavior. The justification for the building and equipment improvements is based on engineering estimates of the estimated savings, not on tenant participation in a utility conservation effort.

b. Cons

The first disadvantage is that this alternative is only half of a utility conservation program involving only the landlord. This alternative should be implemented on the part of the landlord in conjunction with one of the other four alternatives.

Second, Because this alternative involves only the landlord, there is no incentive for tenant utility reductions. Utility improvements may incentivise the tenant to waste utilities since his wasteful consumption would be offset by the improved utility efficiency.

The third disadvantage is that this alternative has unlimited cost potential for building and equipment efficiency improvements. DoD currently requires an ECIP of less than 6 years for project approval, but there are an unlimited number of utility improvement projects. DoD could spend millions of dollars on utility improvements each year.

Without accurate metering, there is no post construction evaluation of the actual savings.

F. ALTERNATIVE V: METER, BILL FOR EXCESS CONSUMPTION, WITH REWARD FOR CONSERVATION

1. Description

Billing tenants for excess utilities consumed and rewarding those tenants who conserve utilities is Option B of Alternative I proposed in the Report to the Congress: Family Housing Metering Test.

> [This alternative] is identical to [Alternative I: Metering and Billing of Excess Consumption] except that the funds received from excess consumers of energy are not necessarily retained in the FHMA (D). These funds as well as funds originally budgeted for utilities are available for redistribution to the residents who conserve the most energy. [Ref. 3:pg 8-3]

For a more equitable reward system this thesis proposes redistributing 25 percent of the savings realized by the tenants' conservation effort back to those tenants whose utility consumption is below their norm. This concept will be illustrated with a numerical example in V.F 2.b.

2. Economic Analysis

a. *Theory*

This alternative is punitive for the expected 15 percent of the tenants consuming utilities in excess of their norm allowance. It also has an incentive for tenants to consume below their norm allowance and to continue or increase their utility conservation effort. This system is very similar to Alternative II, Meter with Full Payment, in that every tenant has a direct economic incentive to reduce utility use through an operating market mechanism.

This alternative provides a smaller economic incentive for utility conservation than Alternative II. It replaces the allowance in Alternative II with a 25 percent rebate for each tenant consuming less than the utility norm. The punitive costs are also smaller under this alternative than Alternative II because once again the costs for excess utility consumption are marginal costs. The tenant in excess of his norm sees a possible monthly utility bill of $10 - $30. This is a very small monthly charge if a tenant does not wish to modify his lifestyle. Also, for a tenant below his norm, the few marginal dollars (rebate) which is the difference between a tenant's norm and his actual utility usage may not be much of an incentive to continue conserving utilities.

On the margin, the punitive costs of this alternative and Alternative II are the same. The consumer pays the full cost of the consumption in excess of the utility norm. This alternative is analyzed because of its possible attractiveness to Congress. Congress may not be willing to implement a utility allowance for military members in the face of a growing national deficit. Congress may also be enticed into adopting this alternative because of the 75 percent government sharing arrangement with tenants below the norm. Congress must appropriate 100 percent of the funds for military utility allowances under Alternative II with the military member keeping all savings. Under this alternative, the government is guaranteed a reduced utility bill assuming 85 percent of the tenants consume below their norm. This alternative does provide a limited direct economic incentive to both tenants and landlord to implement conservation measures, as in Alternative II. However, the financial incentives to adopt this alternative are greater for the government since it receives a 75 percent rebate on each utility dollar saved.

Several studies, Winett, Kagel, Battalio, and Winkler [Ref. 14], Walker [Ref. 15], Craig and McCann [Ref. 17], Slavin, Wodarski, and Blackburn [Ref. 16], and Counihan and Nemtzow [Ref. 22] suggest that any form of economic incentive for the reduction of utilities is better than no incentive at all. In this case, an economic incentive is provided to all participants; landlord, under-consumer and over-consumer.

b. Example

Appendix D has a detailed example of a monthly utility bill for La Mesa Village. This example assumes that La Mesa Village would have a $147,500.38 monthly utility bill if each tenant consumed exactly his utility allowance. The example assumes that 15 percent of the La Mesa Village population saves $2,205.38 by consuming 10 percent below their utility norm. It also assumes that 70 percent of the La Mesa Village population saves $6,199.32 by consuming 6 percent below their utility norm. In addition, 10 percent of the La Mesa Village population costs an additional $889.83 by consuming 6 percent above their utility norm. Finally, 5 percent of the La Mesa Village population costs $1,083.50 by consuming 15 percent above their utility norm.

After paying the monthly utility bill of $141,069.01, the Housing Administration distributes $1,667.25 to the 710 tenants who consumed less than their norm for the month. The government keeps $4,768.61 as its portion of the monthly utility savings. In this particular example, individual tenants would receive a monthly utility rebate from $1.60 up to $4.46 depending on the size of the individual's conserved utilities.

If the entire La Mesa Village population consumed below their monthly norm, the individual rebates would increase. For example, assume that 30 percent of the La Mesa Village population saves $4,417.84 by consuming 10 percent below their utility norm. The remaining 70 percent of the La Mesa Village population saves $6,199.32 by consuming 6 percent below their utility norm. With these figures, the Housing Administration would have to pay a monthly utility bill of $136,883.22 and have $2,654.29 available for distribution to all 835 tenants. The individual tenant utility rebates would range from $2.12 up to $5.89 for the month with the rebate being directly proportional to the tenant's conserved utilities. The more the entire housing population saves, the more each tenant would receive in their monthly utility rebate.

If the incentive system proposed by Option B of the Report to the Congress is used and the funds collected for excess utility consumption are distributed to the tenants consuming below their norm, the individual tenant utility rebates in the first example above jump up to the incredible range of $4.11 up to $11.43 for the month. This introduces an unusual incentive system. Each tenant wants to consume below his own norm to be included in the monthly utility rebate. However, each tenant wants to encourage his neighbor to consume more than his norm so that the conserving tenant's monthly utility rebate increases. For this reason, this thesis proposes that only the portion of the saved monthly utility costs be redistributed to the conserving tenants and not the funds collected from tenants that consume above their norm.

While this alternative increases the incentive to conserve, it is not clear that it corrects the problems of the 25 percent rebate. There is no direct relation between the tenant's conservation effort and his rebate payment because the amount of his payment depends on the other tenants' actions. In addition, the tenant does not know in advance how many tenants are going to over-consume so that he does not have information necessary to make trade-offs on the margin based on accurate cost information.

3. Implementation

a. *Billing*

The billing system for this alternative would be only slightly more complicated than Alternative I. This alternative would involve collecting money from tenants who consume above their monthly norm and redistributing funds to tenants who consumed below their monthly norm. Since the amount of the monthly rebates are fairly small, it might be better to simply report the accumulated monthly rebate on the utility usage feedback statement. When the tenant vacates La Mesa Village, one of the checkout procedures would be the payment of the accumulated utility monthly rebate. This way, the Housing Administration would not have to process several small monthly checks. They would only process one check for $50 to $100 for each tenant at checkout.

b. *Effect on Tenants*

All tenants, whether consuming above or below their norm, would have an incentive to further reduce utility consumption. Those tenants consuming above their norm may find the penalty payment tolerable and not much of an incentive to reduce their utility consumption. Those tenants consuming below their norm may find the rebate insufficient to entice further conservation efforts. Tenant consumption behavior may not be modified by this alternative.

This alternative would have little impact on morale due to the small amount of money involved each month. Those tenants who have higher alternative uses for their money will conserve utilities and receive a substantial check when they vacate government quarters. Those tenants who value the utilities will continue to consume above their norm and pay their small monthly utility bill.

4. Pros and Cons

a. *Pros*

The first advantage this alternative has over Alternative I is that, like Alternative II, both the tenants (both over and under consumers) and the landlord have a direct economic incentive for conserving utilities. Tenants consuming below their norm are incentivised to continue conserving by a 25 percent utility rebate. Tenants consuming above their norm are incentivised to reduce their consumption by a utility bill. The landlord is incentivised to implement utility conservation measures by retaining 75 percent of the realized utility savings.

The advantage this system has over Alternative II is that another allowance system is not necessary. The Housing Administration retains control of utility funding. Utilities consumed in excess of tenant's norms are paid for by tenants and realized savings are shared with tenants who consume below their norm. This alternative guarantees that the government will never pay more than its annual budget in utility bills. It should consistently realize some savings each month.

b. Cons

The disadvantage of this alternative is that the economic incentives for the tenants, both under and over consumers, are very small (although they are the same on the margin as Alternative II for over consumption). Such small economic incentives may not be sufficient to modify tenant's consumption behavior.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

According to Table 1 in the Report to the Congress, the five alternatives are ranked from highest recommendation to lowest recommendation based on net annual savings or cost.

	Net Annual Savings/Cost
Alt 4: Building and Equipment Improvement	$35,527,000 Sav
Alt 5: Meter / Tradable Permits	$11,571,000 Cost
Alt 2: Meter / Full Payment	$11,657,000 Cost
Alt 3: Meter / Feedback Only	$23,200,000 Cost
Alt 1: Meter / Bill For Excess	$42,320,000 Cost

Based on the analysis in this thesis, the five alternatives are ranked as follows:

	INCENTIVES		
	UNDER NORM	OVER NORM	LANDLORD
Alt 2: Meter/ Full Payment	X	X	X
Alt 5: Meter/ Tradable Permits	X	X	X
Alt 1: Meter/ Bill For Excess		X	X
Alt 3: Meter/ Feedback Only			X
Alt 4: Building/Equipment Imp			X

Only Alternatives II and V provide an economic incentive for all tenants to conserve utilities. Alternative I only provides an incentive for over consumers to conserve but provides no incentive for the under consumer to continue or reduce utility consumption. Alternative III and IV are clearly the worst two alternatives from the tenant's perspective. Neither provides any incentive for the tenants to reduce their utility consumption.

Alternative IV has the unique distinction of only involving the landlord in the utility conservation program. The other four alternatives could each be implemented along with Alternative IV. This would be a better conservation program than Alternative IV by itself.

A general conclusion highlighted by this thesis is the extreme difficulty of assessing the effectiveness or efficiency of conservation measures without accurate metering data. If DoD is serious about reducing its utility costs, the first place to start would be identifying utility wasting facilities and personnel.

B. RECOMMENDATIONS

1. Recommendation Number 1

To comply with the Congressional intent of reducing utility consumption in military family housing units, a full utility conservation program should be implemented. DoD should continue to effect building and equipment improvements. This is the landlords' responsibility toward utility conservation. Alternative II or V should also be implemented to place tenant utility conservation responsibilities with military families living in government quarters.

2. Recommendation Number 2

DoD should meter as many of its facilities as is economically feasible. This accurately measures utilities consumed and helps assess post construction energy improvements. Accurate utility meter readings will allow DoD to identify utility losses in transmission lines and piping as well as identifying utility wasting facilities and personnel.

3. Recommendation Number 3

DoD should initiate a long-term study involving tenant utility consumption modification. There currently is no good literature or data on actual savings in metered housing. DoD should pick a location with more than 300 units, meter them and initiate one of the four alternatives designed to modify tenant consumption behavior. By metering one housing site, DoD could systematically implement all five alternatives and obtain numerical data on the utility savings over a long period of time. Comparing the test results from each of the alternatives could help establish a DoD wide utility conservation policy.

4. Further Study

A suggested follow on study to this thesis would collect data from one Naval base to evaluate the effectiveness of the current Navy utility conservation program. Analyzing utility conservation at a Naval base and the actual utility savings could possibly show that implementing Alternative IV: Building and Equipment Improvement is a misguided policy.

APPENDIX A

LA MESA VILLAGE

Housing Area	Year Built	No. of Bedrooms	No. of Units
WHERRY	1952-1953	2	44
		3	337
		4	69
CAPEHART	1961	2	4
		3	122
		4	24
'65	1965	3	160
'69	1969	2	24
		3	62
		4	32
TOTAL			878

LA MESA
HOUSING
AREA

APPENDIX B

CIVILIAN LITERATURE BACKGROUND

In the Denver area, metering reduced total annual water use by about 20 percent. Over a 3-year period, water use in metered homes averaged about 453 gallons per day. Water use in flat-rate homes (master metered) averaged about 566 gallons per day. [Ref. 19:pg 1-3]

Samuel Nelson found that the average electricity savings was about 20 percent after switching from master metering to individual metering. In 28 studies conducted from 1969 to 1976, he found that savings were smaller when electricity was also used for heating than when it was only used for lights, appliances and possible cooling. [Ref. 18:pg 3]

Clive Seligman and John Darley studied electrical use in 29 physically identical three-bedroom homes. Before feedback began, the feedback and control groups consumed electricity at approximately equal rates. During the feedback period, the feedback group used 10.5 percent less electricity. [Ref. 20:pg 363]

Winett, Kagel, Battalio, and Winkler studied 129 volunteer single family residential households in Texas. They were broken into 3 control groups. Participants were monetarily rewarded for lowering electricity use. One group received a 240 percent rebate for changes in electricity use, another group received a 50 percent rebate and the final group received no rebate. Only the high rebate group significantly curtailed electricity use. It decreased by about 12 percent over the course of the study. [Ref. 14:pg 73]

Samuel Craig and John McCann collected data from 700 New York Metropolitan area residents using a questionnaire. 18 percent of the respondents lived in master metered dwellings. The remaining 82 percent lived in single-metered dwellings. Craig and McCann concluded that individuals living in master-metered dwellings consume on the average 35 percent more electricity than individuals living in comparable single-metered dwellings. The main reason for the higher consumption appears to be the lack of a direct incentive to conserve electricity. [Ref. 17:pg 162]

Counihan and Nemtzow compared three studies and found that savings varied considerably, reflecting differences not only in methodology of each study but in the fuel sources and end use observed in each study. A 1975 study determined that individually metered residences use 26 percent less electricity than master metered ones. The savings reported by electric utility companies, released in a 1977 study, averaged 18 percent with individual metering. A third study, in 1979, found that separate metering saved 15 - 20 percent for electricity; its findings for natural gas ranged from a 7 percent savings to an 8 percent loss. [Ref. 22:pg 1114-1115]

Ritschard and Dickey found building construction so poor for low income public housing that any form of energy conservation measure reduced previous energy consumption levels from 14.5 percent to a maximum of 50 percent in cold climates like Minnesota. [Ref. 24]

APPENDIX C

UTILITY NORM CALCULATION FOR LA MESA VILLAGE

Electricity (Mwhr)

Date	Jan	Feb	Mar	Apr	May	Jun
1991	559	505	493	542	461	422
1990	547	555	573	492	467	487
1989	628	566	608	500	491	524
1988	638	604	575	573	501	502
1987	611	602	597	597	597	531
1986	569	551	536	514	556	508
1985	552	575	615	530	531	485

Date	Jul	Aug	Sep	Oct	Nov	Dec	Total
1991	535	455	552	505	566	579	6,174
1990	350	402	458	419	419	481	5,650
1989	434	480	558	521	537	619	6,466
1988	482	490	506	571	559	590	6,591
1987	504	526	537	541	582	573	6,798
1986	485	489	527	507	626	602	6,470
1985	436	515	516	505	619	644	6,523

The annual average electricity consumption in La Mesa Village is 21,782 MBtu or 6,382 Mwhr. Residential households consume on the average between 400 and 600 Kwhr per month. Using the following breakdown for 2, 3 and 4 bedroom dwellings at La Mesa Village accounts for 6,359 Mwhr annually.

	Units	Monthly Kwhr	Annual Mwhr
2 Bedroom Units	72	475	410
3 Bedroom Units	681	605	4,944
4 Bedroom Units	125	670	1,005
		Total	6,359

Natural Gas (MBtu)

Date	Jan	Feb	Mar	Apr	May	Jun
1991	11425	7541	12465	10267	9194	7104
1990	10489	13887	7991	8566	6322	5546
1989	13755	12075	9503	6021	6122	6081
1988	11752	10023	8567	7545	6731	5532
1987	13464	8852	9133	9133	9022	5842
1986	8799	9721	7306	7355	7458	5250
1985	10907	10710	10128	7684	7397	4846

Date	Jul	Aug	Sep	Oct	Nov	Dec	Total
1991	7117	4436	4289	4516	7325	10214	95,893
1990	3589	3691	4124	4331	4331	7541	80,408
1989	3939	4500	5476	4722	6948	9795	88,937
1988	4745	3988	4566	5795	6860	9586	85,690
1987	4993	4534	4502	4290	5346	6019	85,130
1986	4713	4364	4935	5100	4578	4578	74,157
1985	3790	4477	4392	4888	9029	11171	89,419

The annual average natural gas consumption in La Mesa Village is 85,662 MBtu. Residential households consume on the average between 100 and 400 KBtu per day. Using the following breakdown for 2, 3 and 4 bedroom dwellings at La Mesa Village accounts for 84,653 MBtu annually.

	Units	KBtu/day	KBtu/month	Annual MBtu
2 Bedroom Units	72	230	6900	5,961
3 Bedroom Units	681	265	7950	64,967
4 Bedroom Units	125	305	9150	13,725
			Total	84,653

Water (KGallons)

Date	Jan	Feb	Mar	Apr	May	Jun
1992	6918	6122	6831	7055	8736	8918
1991	6132	5547	5832	6480	7151	6976
1990	6265	5592	6576	6600	7191	6818
1989	7111	6030	6722	6169	7391	6907

Date	Jul	Aug	Sep	Oct	Nov	Dec	Total
1992	10921						
1991	8914	9496	10349	8739	6292	6744	88,652
1990	8407	9558	8589	8796	7196	6539	88,127
1989	8097	8520	7832	9803	6830	5713	87,125

The annual water consumption in La Mesa Village is 87,968 Kgallons. Taking a daily population weighted average for La Mesa Village yields a daily population of 2892 people. This equates to a daily water consumption of 83.3 gallons per person. For ease of calculation, 80 gallons per person per day will be used as the water norm.

$$\left(\frac{87{,}968{,}000\ Gal}{Year}\right)\left(\frac{Year}{365\ Days}\right)\left(\frac{Day}{2892\ persons}\right)=\left(\frac{83.3\ Gal}{person}\right)$$

APPENDIX D

EXAMPLE MONTHLY UTILITY BILL

La Mesa Village contains 878 family dwellings including two, three and four bedroom units. This example assumes that 95.09 percent of the housing units are occupied.

	Units Available	Filled
2 Bedrooms	72	68
3 Bedrooms	681	648
4 Bedrooms	125	119
TOTAL	878	835

The norms established in Appendix C will be used in this example. The utility rates are, $0.064/KWhr (electricity), $0.014/KBtu (gas) and $0.003/Gallon (Water).

The Code used in this example designates the number of people living in the unit. Code 1 means a military member and spouse. Code 2 means a military member, spouse and one child. Code 3 means a military member, spouse and two children. Code 8 means a military member, spouse and seven children.

Using the norms of Appendix C, the previously established utility norms and the previously defined housing codes a typical La Mesa Village monthly utility bill is as follows:

Code		Units	Elec	Gas	Water	Norm Monthly Billing
1	2B	68	$ 2,067.20	$ 6,568.80	$ 979.20	
	3B	80	$ 3,097.60	$ 8,904.00	$1,152.00	
2	3B	260	$10,067.20	$28,938.00	$5,616.00	
3	3B	291	$11,267.52	$32,388.30	$8,380.80	
4	3B	17	$ 658.24	$ 1,892.10	$ 612.00	
	4B	86	$ 3,687.68	$11,016.60	$3,096.00	
5	4B	29	$ 1,243.52	$ 3,714.90	$1,252.80	
6	4B	3	$ 128.64	$ 384.30	$ 151.20	
8	4B	1	$ 42.88	$ 128.10	$ 64.80	
TOTAL		835	$32,260.48	$93,935.10	$21,304.80	$147,500.38

Assuming that 15 percent of the La Mesa Village population (125) consumes 10 percent below their norm, the government would save $2,205.38 in monthly utility costs. Assuming 70 percent of the La Mesa Village population (585) consumes 6 percent below their norm, the government would save $6,199.32 in monthly utility costs. 10 percent of the La Mesa Village population (84) is assumed to consume 6 percent above their norm, resulting in an $889.83 penalty payment. Five percent of the La Mesa Village population (41) is assumed to consume 15 percent above their norm, resulting in a $1,083.50 penalty payment.

15% of Population Under Norm

Code		Units	10% Below	Subtotal
1	2B	10	$14.14	$141.40
	3B	12	$16.44	$197.30
2	3B	39	$17.16	$669.32
3	3B	44	$17.88	$786.81
4	3B	3	$18.60	$ 55.81
	4B	13	$20.70	$269.07
5	4B	4	$21.42	$ 85.67
6	4B	0	$22.14	$ 0.00
8	4B	0	$23.58	$ 0.00
TOTAL		125		$2,205.38

70% of Population Under Norm

Code		Units	6% Below	Subtotal
1	2B	48	$ 8.48	$ 407.23
	3B	56	$ 9.87	$ 552.45
2	3B	182	$10.30	$1,874.09
3	3B	204	$10.73	$2,188.76
4	3B	12	$11.16	$ 133.93
	4B	60	$12.42	$ 745.13
5	4B	20	$12.85	$ 257.02
6	4B	2	$13.28	$ 26.57
8	4B	1	$14.15	$ 14.15
TOTAL		585		$6,199.32

10% of Population Above Norm

Code		Units	6% Above	Subtotal
1	2B	7	$ 8.48	$ 59.39
	3B	8	$ 9.87	$ 78.92
2	3B	26	$10.30	$267.73
3	3B	29	$10.73	$311.15
4	3B	2	$11.16	$ 22.32
	4B	9	$12.42	$111.77
5	4B	3	$12.85	$ 38.55
6	4B	0	$13.28	$ 0.00
8	4B	0	$14.15	$ 0.00
TOTAL		84		$889.83

5% of Population Above Norm

Code		Units	15% Above	Subtotal
1	2B	3	$21.21	$ 63.63
	3B	4	$24.66	$ 98.65
2	3B	13	$25.74	$334.66
3	3B	15	$26.82	$402.35
4	3B	1	$27.90	$ 27.90
	4B	4	$31.05	$124.19
5	4B	1	$32.13	$ 32.13
6	4B	0	$33.21	$ 0.00
8	4B	0	$35.37	$ 0.00
TOTAL		41		$1,083.50

SCENARIO 1: REBATE INCLUDES PENALTY PAYMENT

Under the scenario the Deputy Assistant Secretary of Defense proposed, a utility bill of $141,069.01 would be paid each month with the government receiving $2,356.86 in savings. 710 residents would receive $4,074.51 in total disbursements from the utility rebates, with individual rebates between $4.11 and $11.43. The breakout is as follows:

Utility Norm Cost:		$147,500.38
10% Savings	:	($ 2,205.38)
6% Savings	:	($ 6,199.32)
6% Cost	:	$ 889.83
15% Cost	:	$ 1,083.01
Utility Bill	:	$141,069.01

Payments to tenants under their norm:
[Ind Energy sav] / [Tot Sav] * [Cost + (.25)*Sav]

As an example, a code 3 family that is 10 percent below their norm saved the government $17.88 on this month's utility bill. The code 3 resident would receive $8.67 for this months utility rebate.

$$\frac{(Ind\ Sav)}{(Tot\ Sav)}*(Cost+0.25*Sav)=Rebate$$

$$\left[\frac{\$17.88}{\$2205.38+\$6199.32}\right][(\$889.83+\$1083.50)+0.25*(\$2205.38+\$6199.3$$

Code		Individual rebates 10% Under	6% Under	Total rebates 10% Under	6% Under
1	2B	$ 6.85	$4.11	$ 68.55	$ 197.42
	3B	$ 7.97	$4.78	$ 95.65	$ 267.82
2	3B	$ 8.32	$4.99	$324.48	$ 908.54
3	3B	$ 8.67	$5.20	$381.44	$1,061.09
4	3B	$ 9.02	$5.41	$ 27.05	$ 64.93
	4B	$10.03	$6.02	$130.44	$ 361.23
5	4B	$10.38	$6.23	$ 41.53	$ 124.60
6	4B	$10.73	$6.44	$ 0.00	$ 12.88
8	4B	$11.43	$6.86	$ 0.00	$ 6.86
				$1,069.14	$3,005.36
TOTAL					$4,074.51

SCENARIO 2: ALL HOUSING TENANTS BELOW THEIR NORM

This scenario assumes all 835 military tenants at La Mesa Village consume below their norm for the month. Under this scenario, 30 percent of the population average 10 percent below their norm. The remaining 70 percent of the population averages 6 percent below their norm. This would provide the government a monthly utility savings of $10,617.16. Twenty-five percent would be distributed to the 835 tenants. Under this scenario, the individual rebates drop to between $2.12 and $5.89 for a total disbursement of $2,654.29. There is no income from any penalty payments.

This would seem to suggest that each tenant would encourage his neighbor to consume above his norm so that the tenant consuming below his norm could profit from both the penalty payment and the 25 percent rebate from the actual utility savings - a most peculiar arrangement.

Utility Norm Cost	:	$147,500.38
10% Savings	:	($ 4,417.84)
6% Savings	:	($ 6,199.32)
6% Cost	:	$ 0.00
15% Cost	:	$ 0.00
Utility Bill	:	$136,883.22

Payments to tenants under their norm:
[Ind Energy sav] / [Tot Sav] * [Cost + (.25)*Sav]

A code 3 family that is 10 percent below their norm saves the government $17.88 on this months utility bill. The code 3 resident would receive $4.47 for this months utility rebate, almost half what he received under scenario 1.

$$\frac{(Ind\ Sav)}{(Tot\ Sav)} * (Cost + 0.25 * Sav) = Rebate$$

$$\left[\frac{\$17.88}{\$4417.84 + \$6199.32}\right][(\$0.00 + \$0.00) + 0.25 * (\$4417.84 + \$6199.32)] = \$4$$

Code		Individual rebates 10% Under	6% Under	Total rebates 10% Under	6% Under
1	2B	$3.54	$2.12	$ 70.70	$101.81
	3B	$4.11	$2.47	$ 98.65	$138.11
2	3B	$4.29	$2.57	$334.66	$468.52
3	3B	$4.47	$2.68	$388.93	$547.19
4	3B	$4.65	$2.79	$ 23.25	$ 33.48
	4B	$5.17	$3.10	$134.54	$186.28
5	4B	$5.35	$3.21	$ 48.19	$ 64.25
6	4B	$5.53	$3.32	$ 5.53	$ 6.64
8	4B	$5.89	$3.54	$ 0.00	$ 3.54
				$1,104.46	$1,549.83
TOTAL					$2,654.29

SCENARIO 3: REBATE ONLY 25 PERCENT OF ACTUAL SAVINGS

This analysis proposes to use the simple method of allocating rebates based on 25 percent of the actual utility savings to tenants consuming below their norm. With the same conditions as in Scenario 1, the penalty payment is removed from the rebate equation. The individual rebates drop to between $1.60 and $4.46 with a total disbursement of $1,666.75. The government retains $4,768.61 or 75 percent of the utility savings.

Utility Norm Cost	:	$147,500.38
10% Savings	:	($ 2,205.38)
6% Savings	:	($ 6,199.32)
6% Cost	:	$ 922.67
15% Cost	:	$ 1,123.88

Utility Bill : $141,142.23

Payments to tenants under their norm:
[Ind Energy sav] / [Tot Sav] * [(.25)*Sav]

A code 3 family that is 10 percent below their norm has saved the government $17.88 on this months utility bill. The code 3 resident would receive $3.38 for this months utility rebate.

$$\frac{(Ind\ Sav)}{(Tot\ Sav)}*(0.25*Sav)=Rebate$$

$$\left[\frac{\$17.88}{\$2205.38+\$6199.32}\right][0.25*(\$147500.38-\$141142.23)]=\$3.38$$

Code		Individual rebates 10% Under	6% Under	Total rebates 10% Under	6% Under
1	2B	$2.67	$1.60	$ 29.00	$ 83.52
	3B	$3.11	$1.87	$ 38.76	$108.64
2	3B	$3.25	$1.95	$132.60	$371.28
3	3B	$3.38	$2.03	$157.08	$436.56
4	3B	$3.52	$2.11	$ 11.22	$ 27.00
	4B	$3.91	$2.35	$ 52.13	$144.00
5	4B	$4.05	$2.43	$ 16.72	$ 50.20
6	4B	$4.19	$2.51	$ 0.00	$ 5.22
8	4B	$4.46	$2.68	$ 0.00	$ 2.82
				$437.51	$1,229.24
TOTAL					$1,666.75

Scenario 3 shows that when 15 percent of the La Mesa Village population consumes above their norm, the remaining 85 percent of the tenants receive utility rebates ranging from $1.60 up to $4.46. If all the La Mesa Village tenants consume below their norm, the individual utility rebates increase to between $2.12 and $5.89. This is a positive incentive for all the tenants to consume utilities below their monthly norm.

APPENDIX E

GLOSSARY

- BAQ - Basic Allowance for Quarters, an allowance for monthly rent and utilities provided to military members renting housing in the civilian community.

- BAS - Basic Allowance for Subsistence, an allowance provided to all military members to defray the cost of monthly food bills.

- CNET - Chief of Naval Education and Training

- DoD - Department of Defense

- ECIP - Energy Conservation Investment Program, DoD's engineering program which analyzes the investment potential for energy conservation programs based on a payback period of 6 years or less.

- Energy Audit Report - A monthly energy report for each Naval Activity which monitors electricity and gas consumption.

- FY - Fiscal Year, beginning 1 October each year.

- Individual metering - Each dwelling has its own meter for electricity, gas and water.

- Kgal - Kilo gallons, 1000 gallons.

- Kwhr - Kilowatt-hours, 1000 watt-hours (a measure of electrical power consumption).

- Market Mechanism - An economic condition where price determines quantity consumed by the purchaser.

- Master metering - One set of meters monitors the total consumption of utilities for a housing complex.

- MBtu - Mega British Thermal Units, the term for the measure of heat generated by natural gas, in units of one million British Thermal Units.

- NAVFACENGCOM - Naval Facilities Engineering Command, the Naval Command responsible for Naval real estate management, energy conservation programs and all Naval military housing facilities.

- Norm - A set criteria level for utility consumption against which tenant consumption is compared.
- OPEC - Organization of Petroleum Exporting Countries, Arab countries which export oil.
- Potable - Drinkable water.
- RUBS - Resident Utility Billing System, a billing system for submetered dwellings to allocate utility costs to residents based on dwelling square footage.
- Submetering - More than one dwelling on a utility meter but less than all dwellings in the housing complex.
- Utilities - Electricity, oil, gas and water consumed on a daily basis by residents in family housing units.
- VHA - Variable Housing Allowance, a supplemental allowance for BAQ to compensate military members for the local cost of living from city to city.

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Counihan, R. and Nemtzow, D., 1981: ENERGY CONSERVATION AND THE RENTAL HOUSING MARKET, Solar Law Reporter. Market forces have been inadequate to encourage energy conservation in rental housing because of a split between those who own the buildings and those who use the energy. Renters are unwilling to invest in property they do not own. Owners often invest little in energy efficiency measures, either because tenants pay the energy bills or because the owners can pass energy costs along in the rent. Unless accompanied by financial incentives or standards for building energy efficiency, a prohibition on master meters is inadvisable because it would further reduce the incentive for landlords to invest in energy conservation. Barriers to energy conservation are discussed on both sides of the rental housing market. Both tenants and landlords face several barriers to implementing energy conservation from economic to legal aspects.

Craig, C. and McCann, J., 1980-81: CONSUMERS WITHOUT A DIRECT ECONOMIC INCENTIVE TO CONSERVE ENERGY, Journal of Environmental Systems, Vol. 10(2). Individuals living in master-metered dwellings consume more electricity than their counterparts living in single-metered dwellings. Part of the reason is that individuals in master-metered dwellings do not have a direct economic incentive to conserve energy. A sample of master-metered and single-metered individuals is examined to provide some guidance in formulating appeals to achieve energy conservation. Through a New York survey of single-metered and master-metered dwellings, the authors concluded that economic incentives are responsible for encouraging better energy conservation practices in single-metered dwellings.

Crossley, D., 1983: IDENTIFYING BARRIERS TO THE SUCCESS OF CONSUMER ENERGY CONSERVATION POLICIES, Energy, Vol. 8, No. 7. Barriers to energy conservation inhibit or retard changes in current inefficient patterns of energy use. This paper reports the results of a project which identified barriers to energy conservation by individual households. The focus was specifically on non-technical barriers; that is, social, institutional and economic factors which prevent people from increasing the efficiency with which they use energy. Barriers were identified by content analysis of interviews with householders; these barriers were therefore those that were seen as being important from the perspective of the householder. Six categories of barriers were identified on the basis of the circumstances out of which the barriers arose. Distributed among these six categories were 25 different types of barriers. Householders' responses towards energy conservation policy proposals were also assessed. Favorable evaluation of a policy proposal did not necessarily lead to an intention to adopt an energy-conserving practice, presumably because of the existence of barriers to energy conservation. Energy policy makers should examine in detail barriers to energy conservation of the types identified in this paper, and then develop appropriate policy mechanisms to overcome these barriers.

Department of the Navy, 1983: CHIEF OF NAVAL EDUCATION AND TRAINING INSTRUCTION 4100.3A, Chief of Naval Education and Training. The purpose of CNET Instruction 4100.3A is to provide policy, objectives and goals, and assign responsibility for the management of energy for aircraft, vehicles, and shore installations within the NAVEDTRACOM. CNET Instruction 4100.3A is based on the general guidance of OPNAVINST 4100.5B and is used as a benchmark on energy reduction goals envisioned in 1983. The energy conservation goal for shore facilities is set at reducing energy consumption per gross square foot by 20 percent by FY 1985, 25 percent by FY 1990, 30 percent by FY 1995, and 35 percent by FY 2000. This instruction establishes aggressive energy reduction goals, provides guidelines for energy conservation measures, and provides guidance on how to evaluate energy conservation investment programs.

Department of the Navy, 1985: Factors that Influence the Implementation of Energy-Saving Technologies at Naval Shore Facilities, Naval Civil Engineering Laboratory, Port Hueneme, CA. The purpose of this report is to assist the Naval Civil Engineering Laboratory (NCEL) by identifying important factors that influence the adoption and continued use of energy-conserving technologies at Naval shore facilities. The report finds that an "inability to identify energy users and to verify energy savings inhibits effective modifications of behavioral patterns and the introduction of new equipment. Money for installing meters is severely limited, and personnel to read meters is inadequate".

Department of the Navy, 1974: FAMILY HOUSING ENERGY CONSERVATION HANDBOOK, Naval Facilities Engineering Command. This publication discusses the role of the Commanding Officer, Public Works Officer, and housing occupant in the promotion of conservation of energy at Navy activities with family housing management responsibilities. It has been prepared to provide those involved with methods for conserving energy and for promoting effective communications with activity personnel to obtain their cooperation.

Department of the Navy, 1988: NAVFACINST 4100.8A, Naval Facilities Engineering Command, Alexandria, VA. The purpose of NAVFACINST 4100.8A is "to establish Naval Facilities Engineering Command (NAVFACENGCOM) policy and goals and assign responsibility for the management of energy resources at NAVFACENGCOM shore installations". This instruction mirrors the shore establishment energy reduction goals set forth in OPNAVINST 4100.5C. This instruction tasks NAVFACENGCOM to optimize energy cost through cost-effective metering, control and management of facility energy systems to curb waste. The instruction further stipulates that, "No restrictions shall be levied on Navy family housing which would reduce quality of life below that normally available to families in the civilian community".

Department of the Navy, 1986: OPNAVINST 4100.5C, Office of the Chief of Naval Operations, Washington, D.C. The purpose of OPNAVINST 4100.5C is "to revise policy, objectives, goals, and assign responsibilities for the management of energy for non-nuclear ships, aircraft, vehicles, and shore installations. This is a major revision to OPNAVINST 4100.5B". This instruction sets the goal for buildings to reduce adjusted energy consumption per thousand gross square feet by 6 percent by end FY 1990, 12 percent by end FY 1995, and 15 percent by end FY

2000. This instruction relaxes previous energy reduction goals which were not attainable and establishes new goals.

Department of Defense, 1980: REPORT TO THE CONGRESS: FAMILY HOUSING METERING TEST VOLUME I, Office of the Deputy Assistant Secretary of Defense (Installations and Housing). This voluminous document is the family housing metering test feasibility report required by Congress in Public Law 95-82 (1977). The report describes the metering test conducted on 10,379 housing units DoD wide, estimates the cost of implementing P.L. 95-82, analyzes potential impacts of the directed metering program and outlines several alternatives to metering all housing units.

Feher, Bela and Little, David and Somer, E.P. 1981: Energy Conservation in Navy Family Housing: A "Master-Metered" Approach, Navy Personnel Research and Development Center, San Diego, CA. The purpose of the study was to develop, implement, and evaluate an intensive behavioral approach for inducing energy conservation in master-metered Navy family housing. A 200-unit housing complex was divided into equal-sized groups and treatment was randomly assigned to one group. Participants received energy-related materials and feedback regarding group energy consumption. An energy coordinator made household visits to participating residences. The participating group significantly reduced their electricity consumption to a level 4 percent below that of the control group. Consumption feedback and personal contact are seen as important supplements to traditional educational approaches to inducing behavioral change.

Gross, Gordon, Harper, Richard and Ahlstrom, Steve. 1975: Energy Conservation Implications of Master Metering Volume I. Midwest Research Institute. A study of master metering of electrical service in apartment and office buildings is reported here. The objectives of the study were to determine (1) the difference between electrical energy consumption by tenants with master metered electric service and those who must pay individual electric bills; (2) the extent and trends of the use of master metering of electrical service in apartment and office buildings; (3) the economic and other factors which influence the initial selection or later conversion to master or individual metering; and (4) to provide and evaluate policy alternatives which control the practice of master metering.

Little, David and McCabe, Kevin and Mills, Shelley and Feher, Bela and Somer, E.P. 1981: Energy-Related Attitudes of Navy Family Housing Residents, Navy Personnel Research and Development Center, San Diego, CA. The purpose of the study was to assess the energy-related attitudes, opinions, and practices of Navy family housing residents. Residents of five family housing installations located throughout the United States were surveyed. Emphasis was directed toward the evaluation of energy-related attitudes, housing problems, variables affecting conservation, and energy consumption practices. Residents' attitudes were generally of a proconservation nature, although substantial discrepancies were evident. Residents saw conservation information as most promotive of conservation; and the lack of information about energy costs and consumption and the structural soundness of the housing, as the greatest hindrances to conservation. Most residents reported they performed both one-time and recurring conservation-oriented practices. However, considerable room remains for increasing performance rates of both kinds of practices. Recommendations included implementing an educational program aimed at forming proconservation attitudes and conveying information about energy-efficient practices, utility consumption and costs. Structural maintenance and modifications should be integrated with educational efforts.

Magat, W., Payne, J., Brucato Jr., P., 1986: HOW IMPORTANT IS INFORMATION FORMAT? AN EXPERIMANTAL STUDY OF HOME ENERGY AUDIT PROGRAMS, Journal of Policy Analysis and Management, Vol. 6, No. 1. Among alternative regulatory responses, information provision programs are receiving increasing attention despite the decidedly mixed evidence about their effectiveness. This paper provides detailed experimental evidence to demonstrate that for one important example of an information program, the use of energy audits to stimulate residential energy conservation, the effectiveness of the program is highly sensitive to the information processing behavior of the users of the information. Simple changes in the format of the information provided to homeowners produced marked improvements in the efficiency of consumer choices. The study illustrates Stern's conclusion in a recent issue of this journal that laboratory experimentation provides a useful alternative to model-based analysis of natural experiments, especially for policy design issues involving information acquisition and processing. The paper also offers conclusions about improving the effectiveness of home energy audits, as well as the entire class of information provision programs.

McClelland, Lou., 1980: Encouraging Energy Conservation in Multifamily Housing: RUBS and Other Methods of Allocating Energy Costs to Residents. Institute of Behavioral Science. This report was written to inform policy makers, state regulatory agencies, utility companies, apartment owners, apartment managers, and apartment residents about methods of encouraging energy conservation in multifamily housing by allocating energy costs to residents. Its special focus is on methods appropriate for use in master metered buildings without equipment to monitor energy consumption in individual apartments. However, the report also discusses several devices available for monitoring individual energy consumption, plus methods of comparing the energy savings and cost effectiveness of monitoring devices with those of other means of promoting conservation.

Nelson, S. H., 1981: Energy Savings Attributable to Switching from Master Metering to Individual Metering of Electricity, Argonne National Laboratory. The data in this study indicates there are significant differences in electricity savings and suggest that these result from the way electricity is used. Based on a format from an earlier literature review, this study shows that savings are smaller when electricity is also used for heating than when it is used only for lights and appliances or only for lights, appliances, and cooling. Based on the average of these best guesses, the average electricity savings are about 20 percent. However, as discussed in the study, a significant portion of the differences in savings is due to differences in electricity price.

Public Law 95-82, 1977: On 1 August 1977, Congress authorized the installation of energy consumption metering devices on military housing facilities. The Secretary of Defense was directed to establish a ceiling for energy consumption (norm) and then charge housing occupants for energy consumed in excess of the established ceiling. Before charging any housing occupant the Secretary of Defense was directed to conduct a test program to determine the feasibility of charging occupants for excess energy consumption.

Ritschard, R. and Dickey, D., 1984: ENERGY CONSERVATION IN PUBLIC HOUSING: IT CAN WORK, Energy Systems and Policy, Vol. 8, No. 3. A large and growing portion of expenditures for public housing consists of energy expenses, which have risen primarily as a result of increasing prices. Studies have concluded that significant cost and energy savings may be made through the improvement of the physical condition of the public housing stock. Our research shows that weatherization and retrofit programs have been established by some local public housing authorities and that results have been encouraging. Widespread adoption of such programs is hampered by difficulties in obtaining relevant technical data.

Seligman, C. and Darley, J., 1977: FEEDBACK AS A MEANS OF DECREASING RESIDENTIAL ENERGY CONSUMPTION, Journal of Applied Psychology. The present study tested the hypothesis that providing immediate feedback to homeowners concerning their daily rate of electricity usage would be effective in reducing electricity consumption. In the 29 physically identical three-bedroom homes used in the study, central air conditioning is the largest single source of electricity usage during the summer. Accordingly, it was possible to predict the household's expected electric consumption in terms of the average daily outdoor temperature. Feedback was expressed as a percentage of actual consumption over predicted consumption, and it was displayed to the homeowners four times a week for approximately 1 month. The results confirmed the hypothesis. Before feedback began, the feedback and control groups were consuming electricity at approximately equal rates. During the feedback period, the feedback group used 10.5% less electricity. The effectiveness of the feedback procedure is discussed in terms of its cuing, motivational, and commitment functions.

Slavin, R. and Wodarski J., 1981: A GROUP CONTINGENCY FOR ELECTRICITY CONSERVATION IN MASTER-METERED APARTMENTS, Journal of Applied Behavior Analysis, Vol. 4, No. 3. Two studies evaluated the effects of a group contingency on electricity conservation. In Study 1, residents of 166 apartment units in three towers held meetings and received biweekly payments of the value of electricity saved compared to predicted use. The group contingencies were initiated in each tower in a multiple-baseline design. The program produced substantial savings in one tower (11.2% of temperature-adjusted baseline), moderate savings in another (4.0%), and minimal savings in a third (1.7%). Overall, the residents saved 6.2%. In Study 2, residents of 255 apartment units, also in three towers, received the same treatment, except only 50% of the value of their savings were paid, and they received a one-time bonus of $5 for using >= 10% less than baseline. Towers in Study 2 showed savings of 9.5%, 4.7%, and 8.3%, an average of 6.9%.

Walker, J., 1979: ENERGY DEMAND BEHAVIOR IN A MASTER-METERED APARTMENT COMPLEX, Journal of Applied Psychology, Vol. 64, No. 2. In a master-metered apartment complex, electricity use is metered at a single point for all tenants so that tenants do not pay energy bills based on their individual use. This article reports the results of an experiment with such a complex. The experiment demonstrates the successful development of an alternative method for making tenants liable for their own energy use. The experiment was conducted in a 176-unit master-metered apartment complex with a resident population of approximately 325. A similar complex served as a control. Tenants, whose apartments were checked at random, were paid cash awards for meeting a specified energy conservation checklist. A comparison of samples, designed to monitor electricity consumption behavior during preexperimental and experimental periods, showed statistically significant changes in behavior between the two periods. Comparing electricity use in the experimental complex with electricity use in the control supported a hypothesis of significant reductions in electricity use by the experimental complex.

Walton, Dennis L., 1977: Costs and Benefits of Extensive Electricity Metering at the Naval Postgraduate School, Monterey. M.S. Thesis (Tibbitts, Advisor), Dept. of Administrative Sciences, Naval Postgraduate School, Monterey, CA. Lt Walton's thesis provides a brief history of utilities conservation and a background on electricity metering in the Navy. A cost analysis is made of the savings that would be required to justify installation of meters in the operational area of the Naval Postgraduate School, Monterey, California, using net present value techniques. Cost data from a metering project at Pacific Missile Test Center, Pt. Mugu, California forms a basis for this analysis. The analysis indicates that meters would be justified at the school if an annual savings of electricity resulting from metering could be realized in the range of 2.1% to 7.4%. Lt Walton's thesis concludes that similar analyses should be conducted at other Navy installations to determine the amount of electricity savings that would be required to justify metering.

Weimer, D. and Vining, A. Policy Analysis: Concepts and Practice. Englewood Cliffs: Prentice Hall 1992. Within a useful and expansive framework for implementing policy analysis, this text introduces students to the practices of public policy while providing a strong conceptual foundation. This Second Edition gives practical advice about how to conduct policy analysis, and it demonstrates the application of advanced analytical techniques.

Winett, R., Kagel, J., Battalio, R., and Winkler, R., 1978: EFFECTS OF MONETARY REBATES, FEEDBACK, AND INFORMATION ON RESIDENTIAL ELECTRICITY CONSERVATION, Journal of Applied Psychology, 1978. In this study, conducted during the summer months in Texas, 129 volunteer participant households were assigned to one of five experimental conditions: a high monetary rebate condition in which participants received conservation information, weekly written feedback on their electricity use, and monetary rebates amounting to a 240% price change in electricity; a low monetary rebate condition with the same structure as the high rebates except payments amounted to a 50% price change; a weekly feedback condition in which participants also received information but no rebates; an information condition; and a control condition. The dependent measure was percentage reduction in electricity use base on actual weekly meter readings by the research staff. Only the high rebate condition significantly curtailed electricity use by about 12% over the course of the study. Elasticity estimates suggested limited responsiveness in electricity consumption to price changes. Questionnaire data showed a pattern in which actual reduction in electricity was associated with planning a conservation program, attending to feedback, and modifying air conditioning use.

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